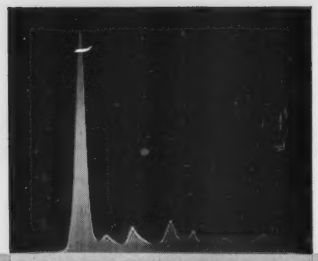
SCIENCE

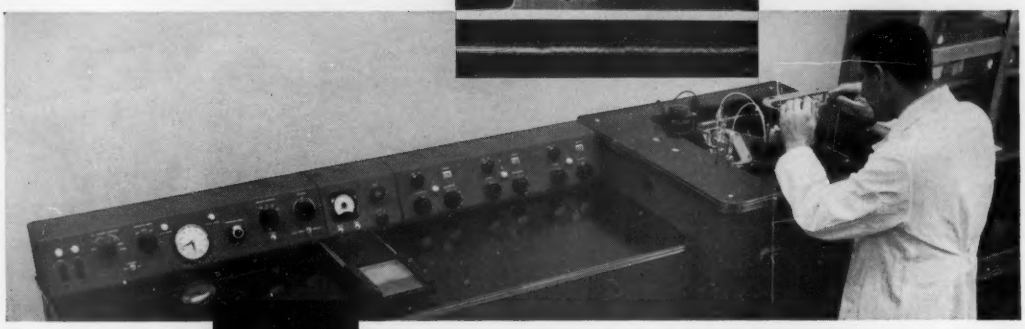
27 March 1959

Volume 129, Number 33

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



Electrophoresis of human serum diluted 1:6; ascending boundaries. Inclined knife-edge schlieren and Rayleigh fringes.



Typical reference fringe pattern obtained from standard production model.

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S-53

Karl Pearson...on mystery versus ignorance

"Does science leave no mystery? On the contrary, it proclaims mystery where others profess knowledge. There is mystery enough in the universe of sensation and in its capacity for containing those little corners of consciousness which project their own products, of order and law and reason, into an unknown and unknowable world. There is mystery enough here, only let us clearly distinguish it from ignorance within the field of possible knowledge. The one is impenetrable, the other we are daily subduing."

—*Grammar of Science, 1892*

THE RAND CORPORATION, SANTA MONICA, CALIFORNIA

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SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., N.W, Washington 5, D.C. Entered at the Lancaster, Pa., Post Office as second class matter under the act of 3 March 1879. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

27 March 1959, Volume 129, Number 3352

SCIENCE

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. The joint journal is published in the SCIENCE format. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

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How To Be Generous Cheaply

Private giving to educational, research, and welfare organizations would greatly increase, so many members of the scientific community have come to believe, if the tax deductions for philanthropy now allowed persons in the top-income bracket were allowed all taxpayers. Under the present laws it costs a wealthy man considerably less to give away a dollar than it does a man of moderate means. When a person with a taxable income of over $400,000 a year gives a dollar to philanthropy, 9 cents comes from his pocket and 91 cents from the tax that he would otherwise have had to pay. When a person with a taxable income of $5000 gives away a dollar, 80 cents comes from his pocket and 20 cents from his tax payment.

An increase in private philanthropy could prove, in turn, to be part of the answer to the problem of increasing the support of educational, research, and welfare organizations without further resort to federal funds. Last year a number of aspects of the proposal to equalize the out-of-pocket costs of the gift dollar were studied in detail in a report prepared for the American Association for the Advancement of Science by the Surveys and Research Corporation. The report, titled "Stimulating Voluntary Giving to Higher Education and Other Programs," considered, among other things, the effects of the previous efforts by Congress to encourage private philanthropy and the possible effects of the new proposal.

During the past decade, Congress has encouraged private giving by increasing the deductions permitted in computing adjusted gross income. In 1952 Congress raised allowable deductions of adjusted gross income from 15 to 20 percent, and in 1954 to 30 percent. These changes in the Internal Revenue Code, however, did not result in an increase in private giving, according to the AAAS report. Income-tax data for the past three decades show that philanthropy as a percentage of income has remained fairly constant. It has been much lower than 30 percent or even 15 percent, staying close to 4 percent.

Some idea of the effect on private giving to be expected from the new proposal may be gained by considering philanthropy as a function of the cost to the giver. It turns out that the higher one goes on the income scale, the smaller the cost of the gift dollar to the giver *and* the larger the percentage of his income that he gives away. According to the AAAS report, in 1953, the last year for which complete data are available, contributions reached 11.6 percent of adjusted gross income for people who had to pay only 9 cents on the gift dollar. To be sure, the cost to the giver may not be the only factor affecting philanthropy, for people with a lot of money may tend to give away a greater percentage of what they have than people in more moderate circumstances.

On 15 January, as a result in part of the AAAS report, Frank Thompson, Jr. (D–N.J.) introduced in the House of Representatives a bill (H.R. 2440) designed to equalize the out-of-pocket costs for persons, and also for corporations, of gifts to institutions of higher education. There may still be room for disagreement about the details of the proposed legislation, for some observers may feel that the tax credits will prove too generous and others may want to broaden the gifts to include contributions to research and welfare organizations. Our guess is, however, that most members of the scientific community would like to see a touch of giftsmanship in the law.—J.T.

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CURRENT PROBLEMS IN RESEARCH

Gibberellins: Stimulants of Plant Growth

Thirty years' work in Japan has initiated world-wide research with a novel group of plant hormones.

Bruce B. Stowe and Toshio Yamaki

In the twenty-odd years since the potentialities of the auxins were first widely recognized, no plant hormones have excited as much botanical and horticultural interest as have the gibberellins. These compounds strikingly stimulate the growth of many plants, promote flowering in some cases, and cause a variety of other interesting morphological and physiological responses. Their use opens up new avenues of approach to botanical problems, and many of their effects promise to be of economic importance in agriculture and horticulture. In this brief introduction to the work being carried on with the gibberellins no attempt has been made to completely cover the rapidly growing literature; papers have been cited only as they seemed especially pertinent. A comprehensive review through 1956 is available (*1*), recent summaries have been published by the British workers (*2, 3*), and some manufacturers of gibberellins have prepared useful bibliographies which include recommended methods of treatment (*4*). Wittwer and Bukovac have evaluated in detail the implications of this development for agriculture and horticulture (*5*). Bibliographical difficulties in this field, arising from the fact that much of the literature was to be found only in Oriental or rare journals, have now been greatly alleviated through the praiseworthy efforts of Stodola, who has assembled in one source abstracts of all papers relating to the gibberellins published prior to 1958 (*6*).

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Historical Background

Oddly enough, despite the recent burgeoning of interest in the gibberellins, these compounds are not new but date from the same period as the first work on other plant hormones. Their discovery can be credited to the late Eiichi Kurosawa, a Japanese plant pathologist who was working in Formosa on diseases of rice. One rice disease, known in Japan for more than a century and a half, especially attracted his attention because of the peculiar fact that *diseased* plants often became 50 percent or more taller than their healthy neighbors in the initial stages of the malady. From this characteristic the colloquial name "*bakanae*" (foolish seedling) disease was derived. The malady is due to an ascomycetous fungus whose sexual form is known as *Gibberella fujikuroi*; the more common asexual stage is known as *Fusarium moniliforme*.

Kurosawa reasoned that some metabolite of this fungus might be responsible for the stimulated seedling growth, and in 1926, after several failures, he succeeded in obtaining a filtered fungal extract which caused growth stimulation of both rice and maize seedlings without any accompanying infection by the fungus (*7*). Kurosawa examined this response and showed that it was brought on by a heat-stable substance found only in media in which the bakanae fungus, but no other fungi, had grown. These observations were soon confirmed by several other investigators in Japan, and they and Kurosawa delineated the gross chemical properties of the active material. Much of their work was published in Western languages, and some of it reached abstracting journals, but it unaccountably failed to arouse interest outside of Japan. This is especially difficult to explain when it is realized that the auxins, another group of hormones which had also been detected in fungi, were attracting wide attention at the same time (*8*).

Upon his return to a new position at the Imperial Agricultural Experiment Station in Japan, Kurosawa encouraged Teijiro Yabuta (Fig. 1), who had been studying fungal metabolism, to investigate the problem of the active material in *Gibberella* cultures. Yabuta took this task with him to the University of Tokyo, where he and his assistant Kannbe sought to isolate the bakanae substance. Their investigation was hindered by the presence of a strongly growth-inhibitory material, and it was further retarded by Kannbe's untimely death. But in 1930, the growth inhibitor (fusaric acid) was isolated, and later Yabuta was joined by Takeshi Hayashi and Yusuke Sumiki (Fig. 1) in further work on the growth-promoting substance. In 1935 Yabuta announced the isolation of a crystalline active material, which he named gibberellin after the fungus from which it was isolated (*9*). Since that time these three investigators and their collaborators have published over forty papers on the bakanae substances and related topics.

Investigations of the chemical nature and biological properties of gibberellin were immediately begun. But due to the difficulty of culturing sufficiently large quantities of the fungus, the work was limited by the small amounts of the pure material isolated. And due to the war,

publication of the results obtained failed to reach Occidental readers. However, the war also stimulated the great development of techniques for the mass culture of fungi in antibiotic production. And in the meantime it had become clear that hormones other than the auxins were involved in plant growth and development. Thus, when abstracts of the Tokyo work first became available, in 1950, industrial facilities and scientific interest were ripe to exploit the Japanese development.

In the United States, the first exploratory work on the gibberellins was performed at the biological warfare center at Camp Detrick, Maryland (*10*). Large-scale isolation of the materials was started shortly thereafter by Stodola's group at the U.S. Department of Agriculture (*11*). Simultaneously, and quite independently, Borrow, Brian, and others at Imperial Chemical Industries in Britain undertook developmental work (*12*). These workers made available for the first time relatively large quantities of gibberellins for experimental purposes. Since then, numerous pharmaceutical firms all over the world have adapted their antibiotic equipment to gibberellin production, and the compounds are now becoming readily available.

Fig. 1. (Left) Teijiro Yabuta, who initiated the research at the department of agricultural chemistry of the University of Tokyo that led to the isolation and characterization of gibberellin, and (right) his collaborator and successor, Yusuke Sumiki.

Chemistry of the Gibberellins

The Japanese studies of the biologically active principle led to the first clue to its basic structure when they established that its degradation products included derivatives of the aromatic hydrocarbon fluorene (*13*). But, although this was not known to the Tokyo group at that time, their isolated gibberellin A, albeit crystalline and in other respects apparently homogeneous, was actually a mixture of several closely related compounds, and they were unable, through their studies, to fix a definitive structure for gibberellin A. On the other hand, the British fermentations produced a different, but homogeneous, product, which the Imperial Chemical Industries group named gibberellic acid (*13*). The first American fermentations yielded two gibberellins, one named gibberellin X and another assumed to be the same as the Japanese gibberellin A (*11*).

These discoveries spurred the Tokyo group to reexamine their material, and they found that it could be separated into three gibberellins—A_1, A_2, and A_3 (*14*). Recently, another, A_4, has been isolated (*15*). Gibberellin A_3 proved to be the same as X and gibberellic acid; A_1, the same as the American A. Thus, there are four clearly established substances possessing gibberellin biological activity which have been found in fungal extracts, and there is evidence that other compounds are present both in fungal extracts and in higher plants (*1, 16*). The separation of these chemically similar compounds remains difficult; column chromatographic methods have been proposed (*17, 18*). Recent reports indicate that these gibberellins do not act alike in biological systems (*19, 20*). For that reason, it has been suggested (*1*) that the commonly used abbreviation GA be made more precise by the addition of subscript numerals—that is, GA_1, GA_2, GA_3, and GA_4.

The best characterized gibberellin is gibberellic acid (all workers have now accepted this name for GA_3). The extensive British work has led to the proposal, by Cross *et al.* (*21*), of the structural formula shown in Fig. 2. This is derived by extrapolation from the degradation product gibberic acid, whose molecular configuration seems to be well established (*22*). The positioning of the lactone group on the cyclohexene ring has been questioned by the Japanese workers (*23*), but a recent British paper answers their objections and seems to assure that the structures shown in Fig. 2 are definitive (*24*). Agreement has been reached on the placement of the secondary hydroxyl (*25*). The complex lactone ring seems to be essential for biological activity, since potency is lost when it is opened and gibberellenic acid is formed (*26*). Mild acid conditions lead further to the evolution of carbon dioxide, aromatization of the cyclohexadiene ring, and Wagner-Meerwein rearrangement to gibberic acid (*21*). Since gibberic and gibberellenic acid are so easily produced from gibberellic acid, they are common contaminants of the commercial material, their presence being betrayed by ultraviolet absorption (*27*). Gibberellic acid's ready aromatization after lactone cleavage and its over-all structure seem unique; no previously known natural products or synthetic compounds are closely related. Mono- or diacetylation of the hydroxyl groups has little influence on the hormone's action, but it has been found, in the few tests so far reported (*1, 14, 20*), that esterification of the acid group greatly reduces or removes biological effectiveness.

The relationships of the other gibberellins to gibberellic acid are being actively investigated. Gibberellin A_1 has been shown to be dihydrogibberellic acid (*17, 23*), as it is produced by the reduction of the cyclohexene bond in gibberellic acid (Fig. 2). It is the only gibberellin so far identified in higher plants (*16, 28*). Gibberellins A_2 and A_4 are chemically closely related to GA_1 and GA_3, as is a gibberellin (bean factor II) recently isolated from higher plants (*16*), but their structures cannot yet be stated with any certainty. No information on the obviously important stereochemistry of these complex, optically active molecules is yet available. Their metabolism is not known, but acetate

and mevalonic lactone have been implicated as precursors of the fungal biosynthesis (*29*).

Methods of chemical analysis and paper chromatography have been developed (*14, 26, 27, 30, 31*), but they are as yet neither very sensitive nor specific, and they are not capable of separating all the gibberellins.

Stem Length

The most typical action of gibberellin on higher plants is an enhancement of stem length. Growth promotion is restricted to young tissue; mature tissue is not influenced. Often the number of internodes is unchanged by treatment, but the plant becomes much taller and, in the extreme, may become too spindly to support itself effectively. Internode elongation can be so great that bushy plants may grow like vines as a result of gibberellin treatment (*3, 32–34*). Even plants such as lettuce, which has never been known to show the twining habit, have become vines (see Fig. 3) (*35*).

A very striking case of stem growth is the remarkable effect of gibberellin on dwarf plants, which was discovered by Brian and Hemming (*36*). These workers found that dwarf peas could be brought to the growth rate of standard peas through the application of less than a microgram of gibberellic acid per plant. Phinney has extended this finding to show that certain single-gene dwarf mutants of maize will grow to normal height with gibberellin applications (see Fig. 4) (*37*). The response is remarkably sensitive (0.001 microgram per plant is sufficient for a detectable reaction) and can be used for bioassay. A spectacular difference of several hundred percent between treated seedlings and controls may be observed in many dwarf plants a few days after one small application of gibberellin.

The effect on dwarfs points up one of the major problems concerning the action of gibberellin. Not all dwarfs respond, and—more serious—not all nondwarf varieties within a given species react alike. Furthermore, there are as yet unexplained differences in response with the age of the plant (*38–40*), although it can be said that in most instances the growth of young plants is the more strongly stimulated. An understanding of this unpredictable effect of variety and age is necessary before gibberellins can be generally applied for agricultural purposes. Still, the promotion of internodal elongation promises to be of some practical use. For example, gibberellin treatment has increased the yield of hemp (*41*) although not the fiber length (*42*). If fiber length can be influenced in crops like flax or cotton such treatment could be of considerable economic value.

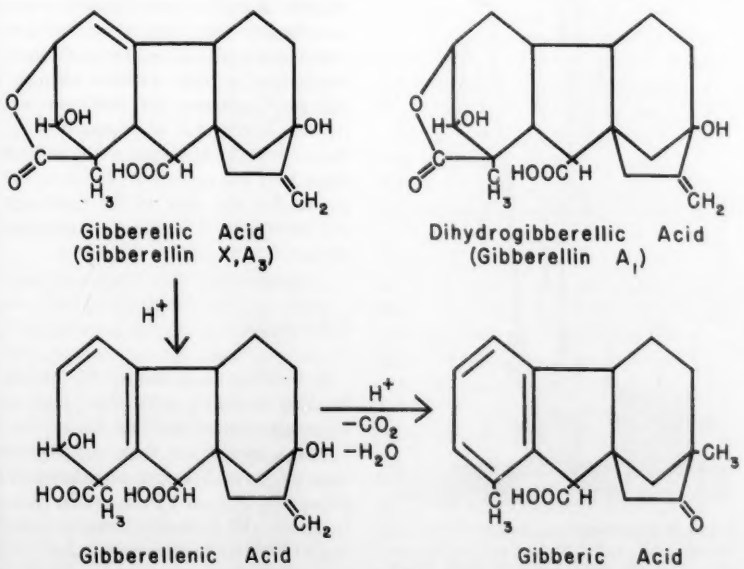

Fig. 2. Molecular structure of gibberellic acid (*21*) and dihydrogibberellic acid (*17*) with the acid-catalyzed degradation sequence of the former compound (*26*), as substantiated by work in Britain (*24*).

Flowering

Another exciting property of gibberellins is their ability to induce flowering in some plants. The requirement of specific day length which must be met for many plants before they will form flowers has been a subject of intensive research. No chemical or isolated hormone, with a few specialized exceptions, had been shown to induce flowering when day lengths were clearly noninductive until Lang made the arresting discovery that gibberellic acid could stimulate flower formation in *Hyoscyamus* in environments under which flowers otherwise never would have formed (*43*). Figure 5 illustrates a similar experiment. This discovery has been extended rapidly to many individuals of the great class of plants which normally flower only when exposed to long days (*44, 45*), as well as to some plants in which vegetative shoot growth is influenced by day length (*46–49*) (see Fig. 6).

Earlier flowering after gibberellin treatment has been observed in plants in which flowering is normally photoinduced as well as in some species that are not sensitive to day length (*50, 51*). In the latter case, flowering may result as a consequence of the plant's reaching optimum size more quickly. The effects on the flowers themselves are less predictable. After treatment, chrysanthemums were larger and bloomed earlier (*52*). In a plant like geranium, with an inflorescence composed of multiple florets, gibberellin nearly doubles the diameter of the inflorescence, largely because of its effect on the elongation of the floret stalks; gibberellin has less effect on the florets themselves (see Fig. 7) (*53*). But in hydrangea, fewer flowers are formed (*54*).

Interestingly enough, gibberellin treatment of the other great class of plants in which flowering is photoinduced—those requiring short days to flower—has no simply explained effect on their flowering. In fact, it is now clear that in some short-day plants gibberellin can inhibit flowering (*55*), but in another short-day plant it increases the amount of flowering without being able to initiate flowering (*56*). This exposes not only an important biochemical distinction between long- and short-day plants but reveals unexpected differences in the latter class which are providing an incentive for further research.

Flowering may also be limited, as in biennials, by the need for cold treatment (vernalization). Here termination of dor-

mancy requires exposure to a definite degree and period of low temperature. Lang discovered that this requirement could also be eliminated by gibberellin (*44*). However, this is not invariably the case, since overwintering grains and other plants have not yet responded satisfactorily (*44, 57*); a light requirement may still have to be met (*58*), and the flower response may be abnormal when it occurs (*59*). Wittwer and Bukovac have pointed out that there still seems to be a specific temperature limit, although it may be raised by gibberellin treatment (*45, 60*). Also, plants may revert to the rosette habit when treatment is stopped (*33*). Thus, further studies of the modified temperature requirement, of interaction with light treatments, of varietal differences, and of flower abnormalities are required before biennials can routinely be expected to yield seed crops the first year.

Other types of cold-released dormancy are known, as in some cases of shoot and bud growth, fruit growth, and seed germination. Some plants cease their growth in the fall and do not resume it until a definite cold treatment has been applied. Gibberellin applications have been successfully used to restore cold-requiring epicotyls (*61*), shoots (*62*), fruits (*63*), and dormant tree buds (*64*) to active growth with partial or complete elimination of the cold requirement. It has been suggested that some varieties of peach and tomato could be grown further south with such treatment (*62, 63*). Similarly, grass can be induced to sprout during cold periods during the spring or fall when normally no growth would occur (*65*). In another type of dormancy, sprouting of tubers before the customary rest period after harvest has expired has been initiated (*66*), and such treatment is effective even if it is applied to the parent plant before harvest (*67*).

Seeds

The dormancy of seeds is a related problem. Many seeds require a period of "afterripening," or cold treatment, or exposure to light, or some other factor or combination of factors before they will germinate. These requirements have been eliminated in certain cases by the action of gibberellin, which annuls the light requirement of lettuce (*68*) (see Fig. 8) and tobacco (*69*) seeds, the cold requirement of peach seeds (*62, 70*), and the light and stratification requirements of *Arabidopsis* seeds (*71*). On the other hand, Bünsow and von Bredow have shown that the light requirement is only partly eliminated in *Kalenchoë* seeds (*72*) and that a marked interaction of gibberellins with kinins exists (*73*). This suggests that new insights into the mechanism of germination will be forthcoming from such studies.

This development has immediate horticultural utility, decreasing as it does the waiting period between generations of plants, and the use of gibberellin seems likely to become a routine practice. Nondormant seeds are also affected; Hayashi showed long ago that gibberellin accelerates germination (*1*). This acceleration is so pronounced that it has been suggested that increase in seed respiration could constitute a bioassay for gibberellin (*74*). The percentage of germination is also increased (*33, 73*). Treatment causing a decrease in the time a young plant stays underground could be beneficial to many plants which are especially susceptible to disease at that time (see Fig. 9) (*75*). If weed seeds were similarly treated, with more uniform germination as a result, a larger percentage of the potential weed population would be available at one time for eradication (*2, 70, 76*).

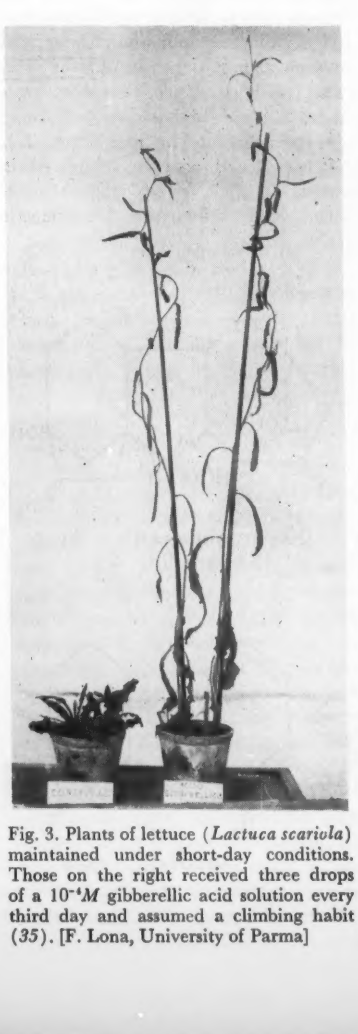

Fig. 3. Plants of lettuce (*Lactuca scariola*) maintained under short-day conditions. Those on the right received three drops of a $10^{-4}M$ gibberellic acid solution every third day and assumed a climbing habit (*35*). [F. Lona, University of Parma]

Fertility

The germination and growth of pollen is also influenced by gibberellin (*77, 78*), as is the induction of parthenocarpy (fruit formation without flower fertilization) (*79*). The production of seedless fruit or the enhancement of yield by means of gibberellin are therefore possibilities, and promising effects have been reported for grapes (*80*) and tomatoes (*51*). It is not necessary that the flower itself be treated; male-sterile tomatoes set fruit when gibberellin was applied to several parts of the plant or even to the soil (*81*). This effect is not without its complications, however. Early work indicated reduction of fertility (*1, 59*), reduction in number and amount of abscission in flowers (*54, 82*), and lowered grain yield (*42*) after gibberellin treatment, and a recent report emphasizes these difficulties (*83*).

Gibberellin-induced promotion of male sterility in hybrid maize has been reported (*84*), and in this case such sterility could be of economic advantage, but in seed crops this possibility could prove a serious deterrent to crop treatment with gibberellin for some other purpose. Kinoshita *et al.*, however, obtained a pronounced increase in the yield of several kinds of beans in many of their experiments; in some varieties of maize and sweet potatoes the yield was increased, in others it was reduced (*85*). Experiments in Michigan on beans and maize were less promising (*86*). It is apparent that the time of the treatment and the variety of the plant are very important determinants of the results.

Cell Division

In its effect on parthenocarpy and in breaking dormancy, gibberellin seems to be stimulating cell division. An increase in cell division in less than 24 hours has been shown in *Hyoscyamus* induced by gibberellin to form a flower stalk (*87*). In plants with formed internodes, some studies indicate that increased growth is due to cell elongation (*1, 87a*), another implicates cell division (*87b*), and others report both are increased (*87c*). Promo-

tion of plant growth and cell division in tissue culture has been reported (*88, 89*), but so has inhibition (*90*). Nickell emphasizes that tissue cultures show diverse responses to gibberellins (*91*). In woody plants a definite promotion of cambium cell divisions has been reported (*92*); the xylem formed lacks vessels unless auxin is also applied, when there is vigorous formation of apparently normal wood (*93*). Cytological observations are of interest in that they show little evidence of cell-division abnormalities or other toxic effects (*1, 78, 88*), but chromosome appearance changes (*94*). Gibberellin, then, cannot be said to act simply as a promoter of cell division or cell elongation; its activities have a more complex basis. It must be noted that gibberellins do not produce the gross deformities and callus formation in plant tissues that can be brought about by auxin or kinetin (*42, 66, 95*).

But unlike auxin, gibberellins can have marked effects on leaf expansion (*1, 42, 96*). Influence on both size and shape is reported (*51, 97*), and an intriguing effect is the production of "juvenile" leaves, formerly known only on young plants, in *Hedera* (*34*) and their more rapid disappearance in *Eucalyptus* (*98*). The promotion of thorn growth on a cactus is also reported (*99*). Leaf expansion has long been a subject of research, and a considerable advancement of our theoretical understanding of the processes involved may be expected to result from further study of these phenomena. Already Kuraishi and Hashimoto have cited data (*100*) which betray an interaction of gibberellin and kinetin in leaf expansion; Humphries' experiments are interpreted differently (*38*). A relationship to the long-known effects of light is indicated (*101*).

Fig. 4. Effect on normal and on a single-gene dwarf mutant of maize of 100-µg doses of gibberellic acid applied at 1- to 5-day intervals during development. Similar experiments have been described (*37*). [Bernard O. Phinney, University of California, Los Angeles]

Agriculture

Applications to leafy crop production are naturally of interest, but although experiments with tea (*1, 102*), mulberry (*103*), and tobacco (*1, 104*) have been reported, no definite conclusions about agricultural utility may yet be drawn from these studies. It should be pointed out that leaf abscission, strongly influenced by auxin, is a distinctly different process and is not affected by gibberellin in the usual test plants (*33, 66, 95, 105*), although leaf abscission has been reported as a delayed effect of treatment (*54*).

A major effect of gibberellins still to be considered is the considerable increase in the dry weight of treated plants which has been noted in many cases (*1, 40, 42, 51, 65*). This is an actual increase in total carbon fixation (*1, 32*), not a promotion of photosynthesis (*106*). Perhaps it is derived secondarily from the increase in photosynthetic area of the plant. A real increase in carbon fixation could markedly affect the yield of most crops—in particular, hay, sugar, and lumber, for example—but the evidence indicates that much more study is desirable. Morgan and Mees increased the first crop of hay by gibberellin application, but the loss in the second crop offset the benefit (*3, 39*). As Brian has pointed out (*2*), many factors are involved; in the case of hay, the increased height of the plant requires changes in mowing practice, the number of new grass shoots is reduced, and there are other complications. The British workers have shown that soil fertilization is an extremely important factor (*32*); the nutrients and quantities involved need to be worked out. The extensive Japanese studies of several forage crops also show a marked initial promotion of growth, which later falls to the level of that of the controls, and confirm the finding that fertilizers have a strong modifying influence (*107*). A possibly useful increase in celery yield has been obtained (*86*). Since the economic rewards here could be large, marked interest is being shown in the carbon fixation aspect of gibberellin treatments.

Tree Growth and Root Growth

The promotion of growth of some trees and woody plants is pronounced (*54, 98, 108, 109*), but evaluation of the long-term results of such treatment will take time. In Nitsch's experiments a second gibberellin treatment had little effect (*47*). In *Populus,* delayed toxic symptoms were noted following initial

stimulation (*110*), and death of meristems was noted in other plants (*54*). Conifers have not been much affected (*33, 46, 108*), but a recent report indicates that day length is an important consideration (*48*).

Despite the enhancement in size of the above-ground parts of many higher plants, much work on gibberellins indicates that they are ineffective or inhibitory with respect to the growth of most roots (*1, 42*). Quantitative tests of roots have in general failed to show any enhancement of root growth, and inhibition is only found at high concentrations (*66, 111*). However, growth of roots of some genotypes of maize is reported to have been stimulated by gibberellic acid (*112*), and so is that of roots of pine seedlings (*113*), indicating that generalizations are also risky in this case. Experiments on the rooting of cuttings are more conclusive and clearly show that not only is root initiation inhibited by gibberellin (*33, 111*) but that the stimulation of rooting caused by auxin is counteracted (*66, 111*). There is evidence of auxin-gibberellin interaction (*70, 114*). Of some interest is the report that gibberellin applications reduced the nodulation of legume roots (*115*). Since nodules are the site of nitrogen fixation, the effect of gibberellin on this important process deserves investigation.

Fig. 5. Effects of gibberellic acid on an annual strain of *Hyoscyamus niger*, a long-day plant, under long (natural) days and short (9-hour) days. All plants resembled the control at the far left at the beginning of treatment. Ten micrograms of gibberellic acid were applied daily to the plants marked "10"; the photograph was taken after 30 days of treatment. The short day ("SD") plant that received gibberellic acid bolted and formed flower buds under this treatment; in this experiment it probably received too small a dose for optimum response. Flower buds formed in both the plants at right ("LD") under long-day conditions; but the effects of gibberellic acid on the stem growth and leaf development of the treated plant are evident (*153*). [E. C. Wassink, Landbouwhogeschool te Wageningen, Netherlands, and G. M. Curry, Tufts University]

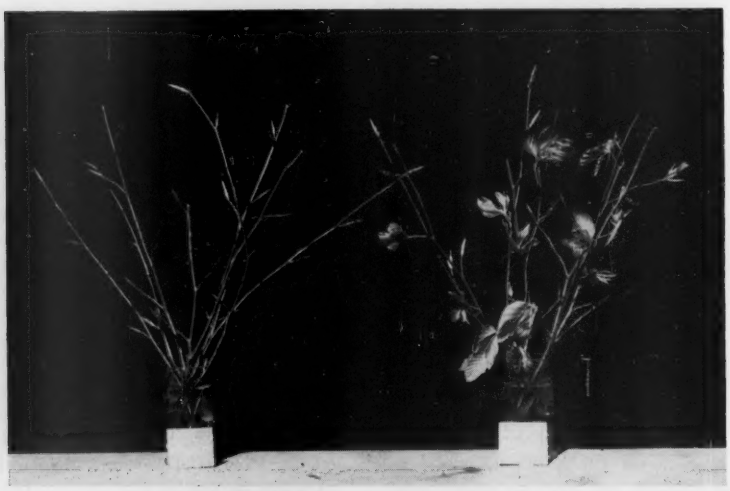

Fig. 6. Induction of bud growth in a day-length–dependent tree by gibberellic acid. The twigs of European beech (*Fagus sylvatica*) were maintained under short-day conditions; those on the left retained their winter dormant conditions, while those on the right sprouted after gibberellic acid treatment (*49*). [F. Lona, University of Parma]

Relation to Plant Metabolism

Metabolic effects of the gibberellins have been sought since the first Japanese studies (*1*). No clear-cut linkage with any metabolic pathway has yet been established, but analyses so far have always shown the greatest changes among carbohydrate constituents (*1, 32, 42, 116*). Another obvious effect is the reduction of chlorophyll content accompanying the chlorosis caused by higher dosages of gibberellin. The fertilizer studies mentioned above (*32*) show that this is in part due to insufficient mineral nutrients. But this and the recently confirmed Japanese report of reduced nicotine content in tobacco (*104*) indicate that some fundamental dislocation of nitrogen metabolism which is not reflected in the nitrogen fraction determinations may be involved. Gibberellin is very probably metabolized slowly by the plant; several studies have followed the rise and fall in growth rate after its application (*36, 82, 117*).

Promotion of the respiration of growing parts of treated plants and of seeds has been reported (*42, 118, 119*). Variations in the level of certain enzyme activities do occur, but gibberellins themselves have not activated isolated enzymes (*42, 119*). The effects of various enzyme inhibitors on gibberellin-induced growth are remarkably similar to the results obtained with auxin (*42, 120*) and implicate the heavy metals and the sulfhydryl groups taking part in the growth process.

Gibberellin is able to reduce the effects of certain plant-growth inhibitors. Kato has shown that both maleic hydrazide inhibition and coumarin inhibition

of cucumber shoot growth are lessened by gibberellin but that root growth inhibition is not (*111*). The maleic hydrazide and gibberellin interaction has been studied by Brian and Hemming, who find less than additive responses and conclude that maleic hydrazide blocks gibberellin action—a conclusion deserving further study (*117*).

Although the effects of the gibberellins have for the most part been sought in higher plants, reports of growth-promoting effects on liverworts (*121*), mosses (*122*), algae (*122a*), and ferns (*123*) are available. Some reports state that fungi and bacteria are not influenced by purified gibberellins (*1, 32, 124*). But it should be noted that applications of gibberellin modified the appearance of plants infected by fungus (*125*) and virus (*126*) diseases; the effect could be on the plant itself rather than on the disease organisms. Gibberellic acid itself is apparently destroyed by soil microorganisms (*32*), but its application to soil is reported to have modified the microbial population so that growth of the nitrogen-fixing bacterium *Azotobacter* was favored (*127*).

A brief report of the effects on a mushroom and on yeast has been made (*33*). These indications, and data which indicate that hormonal levels of gibberellin promote the growth and respiration of the BCG strain of *Mycobacterium tuberculosis* (*128*), suggest that work on microorganisms should not be abandoned. Animal-tissue cultures have not shown any convincing response (*1, 129, 130*), and the first toxicological report indicates that gibberellic acid is tolerated when it is administered to rats and mice in several different ways (*130*). The sphere of gibberellin sensitivity would thus appear to be similar to that of the auxins.

Application to Theoretical Problems

The survey of the effects of gibberellins given above should suffice to illustrate why these compounds have excited popular and scientific interest. But of more importance in the long run is the hope that their use will divulge basic information on the natural processes of growth regulation and development in plants. The natural occurrence of gibberellins in higher plants, suggested in the work of Mitchell *et al.* (*131*) and since demonstrated in a wide variety of plant tissues (*30, 132, 133*), is now conclusively substantiated by two isolations

Fig. 7. Enlargement of a multiple-floret flower head by gibberellin treatment. The geranium plant at right received a foliar spray of 10 parts of gibberellin per million, applied when the buds first began to open and first showed color. The plant at left is an untreated control (*5, 53*). [S. H. Wittwer and Michigan State University]

of dihydrogibberellic acid (GA_1) from beans (see Fig. 10) (*16, 28*).

Preliminary results with another isolated material (bean factor II) indicate that a biochemical pathway limiting growth may be operating among maize mutants, analogous to the growth-limiting pathways long known in fungi, bacteria, and algae (*19*). The hormonal nature of gibberellin is further established by experiments which demonstrate that natural induction of flowers in *Hyoscyamus* is accompanied by the formation of a substance which acts on maize dwarfs like gibberellin (*134*). Lockhart has suggested that in pea seedlings the normal organ of gibberellin production is the tip (*135*); other evidence suggests that gibberellin is also produced after fertilization during fruit formation (*1*), and in tissue cultures (*133*). Sites of active cell division thus are implicated.

Relation to Auxin

The feeling that gibberellins must be natural higher plant hormones has prompted investigations of their affinities with auxin (*33, 42, 66, 95*). These

Fig. 8. Seeds of lettuce moistened in water (left) and in a $10^{-4}M$ gibberellic acid solution (right) after 120 hours in total darkness (*68*). The light that these seeds would normally require to germinate under the conditions of this experiment is no longer necessary after the hormone treatment. [F. Lona]

show that gibberellins cause small responses in straight growth auxin assays with excised plant sections (and none at all in curvature tests), in marked contrast to their strong growth-promoting effect on intact plants. Conversely, auxins strongly promote section growth but cause only minor stimulation of intact plants. This striking difference has yet to be explained.

The toxic effects and promotion of cell division by auxin at high concentrations cannot be duplicated with gibberellin, nor does gibberellin cause the strong inhibition of root growth characteristic of auxin. Auxin and gibberellin act in opposition in the rooting of cuttings, and gibberellin fails to show the typical auxin actions of inhibition of the growth of buds (*66, 95, 111, 136*) and of leaf abscission. On the other hand, auxin fails to act as gibberellin does in promoting flowering, in breaking dormancy, and in accelerating leaf expansion. The remarkable polar transport of auxin is not shown by the gibberellins, which move freely within the plant (*1, 81, 137, 137a*). Thus, there is no doubt that the gibberellins are a class distinct from the auxins in many respects.

Yet, in that both promote parthenocarpy and stimulate internodal elongation, gibberellins and auxins appear to be closely related. Statistical evidence of auxin-gibberellin interaction has been amplified by further data which show that auxin is required for gibberellin promotion of cell elongation (*138*). This has now been simply and elegantly demonstrated by Kuse in experiments with sweet-potato petioles (*137*). Kuse's work clearly indicates that gibberellin does not promote petiole elongation in the absence of auxin but is strongly stimulatory in the presence of endogenous or applied auxin. Simultaneously, his experiments show that gibberellin transport is not polar and is not blocked by triiodobenzoic acid, a potent inhibitor of auxin movement in the plant. Synergism between auxin and gibberellin is also indicated by work with tissue cultures (*89*) and with cambium (*93*).

The implications of such instances of gibberellin and auxin acting together have been discussed by Brian and Hemming, who favor the interpretation that gibberellin is acting to remove an inhibition of auxin-induced growth (*138*). Pilet's report that gibberellin inhibits indoleacetic acid oxidase could indicate that it is thus a means of increasing the auxin level (*139*). However, Brian and Hemming did not find a similar inhibition in their system, and they make the telling argument that synthetic auxins, not attacked by indoleacetic acid oxidase, also promote gibberellin action (*138*). Galston has provided an alternative hypothesis, namely that an endogenous-auxin-sparing action results secondarily from the formation of an indole-

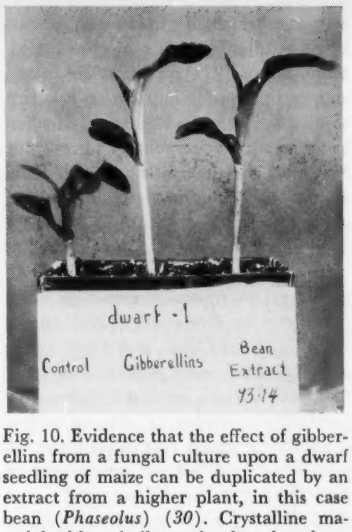

Fig. 10. Evidence that the effect of gibberellins from a fungal culture upon a dwarf seedling of maize can be duplicated by an extract from a higher plant, in this case bean (*Phaseolus*) (*30*). Crystalline material with a similar action has since been prepared from this source (*16*). [Bernard O. Phinney]

acetic acid oxidase inhibitor (*140*). Hayashi and Murakami, however, in essays of extractable and diffusible auxin from several different plants, could find no change in auxin levels after gibberellin treatment and no influence of gibberellin on the conversion of tryptophan to auxin (*141*). Nonetheless, Nitsch found rapid changes in auxin chromatograms after gibberellin treatments (*142*). Since Hayashi and Murakami used the *Avena* curvature bioassay, which is relatively specific for indoleacetic acid, their results do not exclude changes in other auxins. Galston's recent report that gibberellin may have to react with some tissue component before interacting with indoleacetic acid provides further indication that as yet unidentified compounds are involved (*143*) and that all this work may yet be reconcilable on such a basis.

These observations may be related to the finding that the youngest plant tissues are the most responsive to gibberellin in section-growth assays (*42, 144, 145*). This could be due to the presence in these tissues of as yet unidentified metabolites required for optimal growth (*138, 145*), and this interpretation is supported by the unexpected finding that hormonal levels of fatty acid esters considerably enhance auxin-induced growth of pea sections (*146*). All these studies indicate that fruitful insights into hormone action are to be gained from further research on gibberellin-auxin interactions.

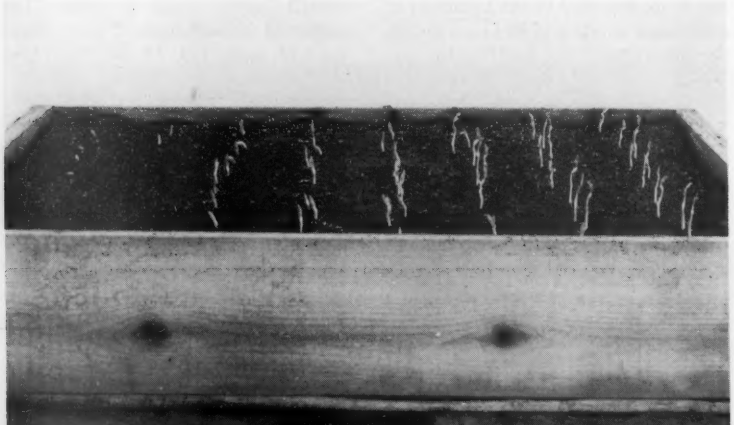

Fig. 9. Effect of gibberellic acid on seedling emergence of Alaska peas. From left to right, seeds received 0, 500, 1000, 2500, 5000, 10,000 and 25,000 parts of gibberellin per million in a Delsan AD slurry applied to the seed coats before planting (*5, 75*). [S. H. Wittwer and Michigan State University]

Interaction with Kinetin

Not to be neglected are the observations that similar ties may exist between gibberellin and kinetin. Lona and Bocchi noted that kinetin reduces the effect of gibberellin in promoting the flower-stalk formation of a rosette plant (*147*), but gibberellin did not reduce kinetin inhibition of auxin-induced pea-section growth (*148*). Moreover, a strong synergism of gibberellin and kinins was shown in seed germination (*73*), and anther cell tissue cultures grew best in a mixture of the two substances (*88*). Since kinins show interaction with auxins in bud inhibition (*136*) and in tissue cultures (*149*), it appears that gibberellin, kinin, and auxin may each influence the action of the others. Further ringing of the changes on these three groups of growth substances with suitable test materials may be expected to divulge whether their actions are sequential or concerted and could provide a major break-through in understanding hormonal control of plant growth and development.

Light

In addition to its contributions to hormonal theory, work with gibberellins is providing new glimpses of the mechanisms by which the quality and duration of incident light influence plant growth and reproduction. Besides its effects with respect to the flowering responses to day length discussed above, light has other morphogenetic effects on plant growth. For instance, red light is inhibitory to internode growth and promotes expansion of leaves in many plants. Examination of these effects has revealed that in peas gibberellin appears to act as if it were removing the red light inhibition (*145, 150*), and Lockhart has suggested that this is the case. But in beans, Downs, Hendricks, and Borthwick obtained data which indicate a much weaker interaction, if any (*151*), and Scott and Liverman (*101*) obtained results on leaf expansion at variance with those of Lockhart. A possible explanation has now been provided by the demonstration that red light promotes growth in beans in the presence of gibberellin—a finding which had not been anticipated—and that there are other differences between species (*152*). Nitsch's (*47*) and Bünsow and von Bredow's (*72*) data also indicate that gibberellin does not simply serve as a substitute for light.

These experiments have a bearing on the flowering problem, since the action spectra of all these responses are closely similar. The influence of lights of other colors on growth and flowering in the presence of gibberellin was studied by Curry and Wassink (*153*), and the results of other preliminary experiments on the influence of spectral quality are available (*145, 152*). In this connection it may be mentioned that light effects are often mimicked by treatment with cobalt ion, which in some respects can also act like gibberellin. However, examination of one system did not show any cobalt-gibberellin interaction (*154*).

It is obviously much too early to be dogmatic about the role of gibberellin in light effects, but a coupling undeniably exists, and further work will certainly be profitable. Experimental analysis of the influences gibberellins have on dormancy and germination is less advanced but is equally promising.

The effects of gibberellin have therefore not been limited to plants; their impact on research has been no less invigorating. Already Brian has put forward a unified theory of plant growth and development based on his analysis of gibberellin responses (*155*), and other syntheses will surely be forthcoming (*156*).

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156. The preparation of this article was assisted in part by a grant from the Committee on Growth acting for the American Cancer Society, Inc., made to K. V. Thimann. We wish to express our thanks to Professor Thimann for his active interest. We are also indebted to Hiroshi Ikuma for assistance with the Japanese translations.

Government Sponsorship of Scientific Research

A cabinet-level department of science could serve to develop support for neglected areas of research.

L. V. Berkner

In the second year of the space age a radical change in American attitudes toward science and education has become noticeable. The Russian success, in a field where America should easily have led, has forced a reappraisal of American attitudes and actions—a reappraisal that is not yet completed.

Today I would ask, first, what new has happened since sputnik? Have we really devised and initiated actions designed to check the deterioration in our national scientific stature? The answer is yes, and we can cite some striking measures that have been undertaken. Then I shall inquire whether the measures to date are adequate. Here the answer is no, and a number of examples of deficiencies will be noted. Finally, I will inquire into the adequacy of certain aspects of our present federal organization in science and consider some alternative measures that seem imperative if serious deficiencies are to be corrected.

Let us turn first, then, to the positive side of the ledger: What have we done as a consequence of sputnik?

Measures Initiated since Sputnik

The appointment of the science adviser to the President and the instatement of the President's Science Advisory Committee directly at White House level have been a major accomplishment. Certainly this step has profoundly influenced all that has followed, for the needs of science, scientific research, and science education can now be understood and discussed at top governmental levels. Scientists finally have a definitive access to the Government. Although this step is not a cure-all, it is certainly an immense step forward that makes consideration of corrective actions more likely.

Second, serious cuts in funds for science and technology made by the Department of Defense a little more than a year ago have been largely restored over the subsequent months. Few people outside the graduate schools have realized the devastating effects of those so-called "economy measures." Over the years since World War II, the Department of Defense had increased its support of work under direction of the universities to about $300 million, of which some $30 million was for research involving graduate students. Having created this university dependence on government, the Department of Defense, in issuing its orders to cut, appeared to be ignoring completely the consequences of such action on the growth of our scientific and engineering manpower. Certainly sputnik saved us from the serious consequences that would otherwise have been inevitable.

Third, the National Science Foundation finally seems to be coming into its own. Established by Congress in 1950, it struggled through its first few years with appropriations far below even its fixed ceiling of $15 million. When the ceiling was lifted by legislative action, the situation improved somewhat. Until the current year, however, its peak appropriation had been $40 million. And of this amount, less than half went for the actual support of science; the remainder went for science education, fellowships, and other activities specified by law. Yet Vannevar Bush, in his report to the President, *Science, the Endless Frontier,* had, as early as 1944, visualized the foundation as growing to a level of $125 million in 5 years. As a direct result of sputnik, its 1959 appropriations total $130 million—certainly a radical recognition of the neglected importance of science and technology. Moreover, in response to recommendations by the National Science Foundation, Congress has authorized all departments to utilize grants as instruments for research support.

Fourth, the 6-year $1 billion student loan bill was passed. For the first time the Government has recognized the gifted student as an asset worth capitalizing. Now the way is clear for all gifted students to realize, more nearly, their optimum capabilities. This is a large entry on the positive side of the ledger.

Fifth, the National Aeronautics and Space Administration was created under civilian auspices and under a law with which few would seriously quarrel. Moreover, substantial appropriations and transfers of funds appear to have initiated this agency on an impressive scale of $250 million. This bodes well for the future of our space research and of a whole assortment of related scientific activities.

Sixth, substantial reorganization of our military research activities has led to direction of research effort into more useful and urgent channels. The creation of the Advanced Research Projects Agency by executive authority is a major step forward. Likewise, the reorganization of the Department of Defense itself is influencing our military effectiveness in a way that will soon be felt. The reorganization seems certain to lead to a more intelligent treatment of some of our most urgent and difficult defense problems.

Seventh, I would mention appropriations made for many facilities that had been knocked out of the budget, to be restored in the shadow of sputnik. The appropriation for our first large precision radio telescope is a case in point. Likewise, research facilities in the field of atomic energy, restored by the Congress over the head of the executive branch, will help to repair the deficiencies that had been for 5 years accumulating in this field, though the facilities in the American research establishment generally still remain grossly inadequate.

Eighth, the post of the Science Adviser to the Secretary of State was filled again after a lapse of nearly 5 years, and a plan to restaff the offices of the science attachés abroad was accepted and funded.

Ninth, Congress has taken action to

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make the federal service more attractive to scientific and technical personnel. Departments can now grant leaves-with-pay for advanced studies, similar to sabbatical leaves granted by universities. Other attractions, such as payment of moving expenses, can now be granted, as has been customary in nongovernmental employment. In adopting these measures, Congress has shown realization of the need for nurturing first-rate men of scientific and technical skill in government.

Likewise, the House of Representatives has created a Standing Committee on Science and Astronautics to review the needs and activities of such agencies as the National Aeronautics and Space Administration, the National Bureau of Standards, the National Science Foundation, and the Smithsonian Institution. For the first time science has been given full stature in the deliberations of a house of Congress. The corresponding new standing committee in the Senate recognizes only astronautics, and an extension of its responsibilities must be awaited.

Finally, people themselves, through committees and school boards, have undertaken revision of the curricula for secondary education. The recent books of Conant, Rickover, and others provide guides and stimulate discussion. The "pipe" electives are being reconsidered, and mathematics and science are coming back into the high school on a substantial scale. Citizens are reexamining the responsibilities involved in education. Likewise, the universities, with the National Science Foundation, are helping to bring textbook and teaching methods up to date. The work at Massachusetts Institute of Technology on physics teaching and the Yale revision of the mathematics curriculum in the high schools are having widespread impact. Communities are reconsidering tax structures to increase the attraction of the teaching profession. The attitude that high schools should be institutions that teach the disciplines of thought and learning, rather than kindergartens for play, is again becoming respectable.

I submit that this is an impressive list of accomplishments. It certainly does not justify the oft-heard comment that "nothing has happened since sputnik." Quite to the contrary, really major measures have been initiated in a little more than a year through genuine effort of the executive branch of our government, of the Congress, and of the people. I must add that I believe that a very great influence in this change has been the science adviser to the President, James R. Killian, and the President's Science Advisory Committee. For the first time, the President and his administration have had direct access to knowledge of the interaction of science on government, an interaction that now influences government more than any other single factor.

Deficiencies

But impressive as this progress has been, it falls far short of meeting the entire intellectual challenge of our time. The drastic nature of the remedies serves to emphasize the depth of our intellectual deterioration as an advanced nation in the presputnik days.

The sputnik has demonstrated that we are engaged in more than a military contest; it is a total contest in which intellectual leadership plays a major role. The contest requires that the victor demonstrate the ability of his system to provide opportunity to accomplish easily those things that men *want* and *admire*. Promise of individual freedom and dignity, and mere material welfare, are not enough. In addition to these essential ingredients, peoples expect a nation that would be great to provide added opportunities to challenge the frontiers of mind and nature—opportunities of the kind that man has treasured in his rise to civilization. The world's recognition of the challenge of space is but a symbol of this need. We can now see more clearly that national superiority comes from positive measures providing sound and widespread education, adequate laboratories, a spirit of daring to embark on new and challenging ventures—in short, all those measures that together spell the intellectual stature that emerges in our citizens from creative opportunity. In this perspective, we can see that the actions taken in the past few months have been interim and urgent measures to check our fall; they are by no means the sole elements of a complete policy to ensure our leadership in the future. But before we discuss some of the major elements of such a policy, we would benefit by looking at some remaining deficiencies that may serve as guides to future action. I shall select some examples from the earth sciences, with which I am most familiar.

We have heard a great deal of talk in recent years about weather control. Certainly, if weather modification on a large scale could be achieved, it would have most profound social, military, and economic consequences. A nation that developed a capability in this field would control, moreover, a powerful potentiality. One would suppose, in view of this potential, that as a matter of minimum common sense we would hasten to exhaust every promising avenue of research on such a problem. Nothing could be further from the fact. Two high-level committees have studied the matter, one established by the National Academy of Sciences and the other composed of the heads of the 14 American departments of meteorology offering graduate degrees in the subject. Both committees have reported, and their reports are in substantial agreement. What is urgently needed to supplement university effort is a major laboratory to provide facilities to attack the meteorological problem on a global scale—large and complex facilities that would extend the opportunity already available to university faculties. The laboratory should provide a giant computer capable of solving problems faster than nature solves them in the atmosphere; a squadron of specially instrumented aircraft to range into areas where special phenomena such as hurricanes, tornadoes, and global atmospheric circulation can be observed and measured; rain towers for observing the physics of rain formation; wind tunnels for studying atmospheric circulation; and laboratories for instrumentation of satellites and analysis of their data. Such a laboratory would cost about $15 million a year for operations. Yet our meteorological research sputters along on $3 million a year, working on insignificant problems while competent scientists sit on their hands awaiting facilities adequate for attacking the really significant problems at hand. All that happens is sympathetic talk.

This is in the face of the fact that the petroleum industry indicates that $100 million would be saved annually if the accuracy of seasonal forecasting could be improved by 10 percent, since it would know where to ship its fuel. Even small advances in meteorological knowledge would yield billions of dollars in the fields of transportation, agriculture, and business. Quite aside from national military and social potentials that can be acquired from meteorological progress, the tax from those billions might well offset some part of our present federal deficit.

The same story can be told for oceanography. The oceans cover three-quarters of the earth's surface. Untold riches

are doubtless contained in them and covered by them. During the International Geophysical Year explorations, a submerged continent was explored, from Tahiti almost to South America. That a whole continent of this kind should remain unexamined until this day is an indictment of our imagination and initiative. Reason dictates that the potential resources of the oceans should be explored and studied by every means. The Soviet Union now has 22 oceanographic vessels, led by the superbly-fitted *Ob* of more than 12,000 tons. Contrast this with the half-dozen yachts of our three or four half-starved oceanographic institutions.

As a third example, the means for thorough survey, in depth, of geological resources and continental structure are at hand. The Soviet Union is reported to be coring its continental strata at the rate of 200 deep holes each year. With such coring and simultaneous survey of geomagnetism, rock magnetism, and gravity, with natural and artificial seismology, geochemistry, radiochemistry, geochronology, and other available geophysical tools, and with the supplementary activities of our oil industry, it would be reasonable to expect that we could map our continent in three dimensions and assess our continental resources in a reasonable length of time. In the face of such a program, the meagerly supported efforts of our competent Geological Survey seem pitiful.

As a further example, one might mention seismology. This powerful phenomenon not only provides the means of characterizing the nature and origin of earth shocks but also supplies the major tool for exploring the earth's interior. With a piddling half million dollars a year, seismology has been unable to grasp the opportunities that science could provide. Detailed knowledge of transformation of earth-shock energy into waves, of phase equalization for intervening wave distortion, of methods of noise reduction, and of instrumentation designed in the light of current techniques of electronics remains but a gleam in the seismologist's eye. Now that such knowledge is urgently needed for our Geneva negotiations, we can only deplore our ignorance and the complacency that has perpetuated it.

One could go on to mention the deficiencies in our antarctic program, where we have fallen far behind the Russians. Yet to the world, Antarctica represents the last great geographic frontier; its scientific exploration remains a symbol of skill and foresight, of courage and endurance that characterizes a nation that would lead.

Scientific deficiencies such as these have one common characteristic. They require integrated planning and support for the science in question on the scale of the problems concerned. They have not yielded, and will not yield, through support of a variety of independent and disconnected research projects on a small scale. Global meteorology can be understood only when it is studied on a global scale. The recording of earthquake phenomena that emerge from an earth shock requires a chain of intimately interconnected instrumentation. Oceanography requires real ships, not yachts. A critical antarctic traverse embraces many sciences and requires years of intimate planning. Scientific problems such as these require a kind of "package" support such as that demonstrated during the International Geophysical Year.

This does not mean that I advocate this form of support for all science. The individual project is ideal for many researchers. But in other fields of science there can be no opportunity for the individual unless the problems can be organized in an integrated package on an adequate scale. The successes of the great nuclear laboratories sponsored by the Atomic Energy Commission, with their specialized and expensive nuclear tools, have been made possible by offering *the individual* opportunity to carry on research on the scale required.

But there is now no adequate organizational machinery in government to initiate or even to conceive of corrective measures for such obvious deficiencies as I have described. What little oceanography the Government does undertake is split between the Hydrographic Office in the Navy and the Coast and Geodetic Survey in the Department of Commerce; both agencies are effectively buried in their departments and are regarded only as something of a nuisance. The research support that is available for oceanographic activities from the Office of Naval Research and the National Science Foundation is distributed among minute and unrelated projects. The Weather Bureau is lost in the Department of Commerce (and incidentally is separated from the ground-water half of the meteorological job because this is a function of the Geological Survey over in the Department of Interior). The Geological Survey is likewise thoroughly subordinated to Interior's major interests—grazing, Indians, and territorial affairs. And so on through the list.

Scientific Activities in Government

What, then, must be done? To analyze this problem, I would tentatively divide scientific activities in government into three parts.

First comes the science and scientific research that is an integral part of the program and objectives of certain government departments and agencies. Such research is directly related to the mission of the departments and hence is essential to their growth and evolution. Thus, the Department of Defense *must* have its supporting research for defense and must, furthermore, sponsor pure research in order to experience the revitalization that science can provide. To cut off the Department of Defense from access to the ideas that renew its vitality would be to damage our defense irrevocably. Likewise, the very lifeblood of the Department of Agriculture is scientific research in agriculture, biochemistry, plant and animal biology, soil chemistry, and so on. Similarly, in many departments one finds activities in scientific research, conducted or sponsored by the department concerned, that are necessary for its intelligent and healthy growth.

The second major government scientific activity is research support. The Government supports a variety of scientific programs in many fields for the sole reason that such support helps to maintain the vitality of American science and technology itself. These are primarily the programs of grants and contracts of the National Science Foundation and the Department of Health, Education, and Welfare. They are frequently described as "extramural" programs of government, because their purpose is to help assure the continuation of free, uncommitted research in colleges, universities, and research institutions. These agencies support graduate students and the individual pure research studies of professors. They contract for the basic laboratory facilities that are necessary to a balanced American scientific activity. These agencies are not "operating" agencies in the usual sense but, rather, have certain broad responsibilities with respect to the general welfare, including not only the encouragement of scientific research but the support of science education to the extent needed to keep America intellectually strong.

The third federal scientific function is represented by those federal services that cut across state boundaries and departmental interests and must, therefore, be performed by the Federal Govern-

ment. There are a variety of such agencies that must provide very general technical services, based on science, that have no special relation to any single department of government but are applicable to all departments and to the country and its business as a whole. Among the agencies performing such services are the Weather Bureau, the National Bureau of Standards, the National Bureau of Standards' Central Radio Propagation Laboratory, the Coast and Geodetic Survey, the Hydrographic Office, the Geological Survey, the Office of Scientific and Technical Information, the Antarctic Offices of the Navy Department and the National Science Foundation, the Fish and Wildlife Service, and the Naval Observatory. These agencies provide those technical and scientific services that are the normal functions of government with respect to its citizens everywhere. They have no real organic relation to the departments with which they are individually associated but find themselves assigned to one department or another largely through historical accident.

Let me summarize, then, the three parts into which I have divided federal responsibility for science for purposes of this analysis: (i) the organic research activities of the departments that are integral and vital to the achievement of department objectives; (ii) external federal support of scientific research and education, conducted by nongovernmental organizations, universities, and laboratories and unrelated to any direct organic responsibility of the supporting agency; (iii) governmental scientific and technical services not principally involved in attaining existing department objectives or strongly related in the organic sense to the functions of a single federal department but of the utmost importance to the Government and the people as a whole.

This third responsibility is not now well discharged by the Government, nor can it be, for a number of obvious reasons. (i) Since the agencies concerned do not vitally participate in striving to attain the organic objectives of the departments concerned, they are "stepchildren" and something of a nuisance to their individual departments. (ii) The organizational distribution of interrelated scientific responsibilities among a variety of departments prevents the close collaboration that is imperative to the success of these services on matters of overlapping scientific and technical interest. (iii) These agencies are at a vital disadvantage in obtaining budget support in competition with other bureaus more closely related to individual departmental objectives. (iv) Since these agencies are minor departmental responsibilities, departmental heads have little knowledge of their real importance. Therefore, appeals for corrective action are not adequately understood or interpreted by departmental administrators.

Department of Science and Technology

The present organization of these vital activities has grown haphazardly over the past century. The time has come when organizational change is imperative. I submit, therefore, that a new federal Department of Science and Technology should be organized to bring the agencies of this third category together, with the objective of adequately developing the broad scientific and technical services of government to meet the needs of today.

Such a department might well include the following divisions, among others: Division of Physical Sciences and Standards; Division of Oceanography; Division of Meteorology, Climatology, and Water Resources; Division of Continental Structure and Resources; Office of Scientific and Technical Information; Government Map Service; Office of Time, Geodesy, and Astronomy; Division of Continental Fish, Wildlife, and (perhaps) Conservation; Division of Radio and Outer Atmospheric Research; and Office of Polar Activities.

The creation of such a department would centralize government responsibility for vital scientific functions that are now performed to an extent that is most inadequate in the light of current needs of science and technology. It would bring together closely related scientific responsibilities so that their natural relations could be exploited. Above all, it would provide the means of extending our leadership to scientific areas where we are now surpassed by other nations.

In advocating such a department, I do not propose that it should try to set up government laboratories to do the job at hand. This would defeat the very objectives of broadening the base of American science and providing opportunity to men of great skill wherever they may be. Rather, the department should be a focus for the now neglected responsibilities in American science. In sponsoring scientific research, a Department of Science and Technology might well emulate the successful pattern of the Atomic Energy Commission in contracting to sponsor national laboratories or institutes in fields of meteorology, theoretical geophysics, polar research, and the like. Certainly I would not preclude government operation and expansion of such essential agencies as the National Bureau of Standards and the Naval Observatory. But, wherever possible, research facilities should be organized as a supplement to university and institutional activities and should be easily accessible to the faculties of such institutions.

One may ask why I have not included the National Science Foundation in such a proposed Department of Science and Technology. I believe that the objectives of the National Science Foundation are radically different from those of a Department of Science and Technology. Such a department is designed to provide government services in science and technology that are essential and must be provided on a nationwide basis. It *must* be closely related to operations at every turn. Its research activities are focused by those responsibilities. On the other hand, since the National Science Foundation functions solely in the area of extramural research, it is and should continue to be nonoperational. Its funds for grants and contracts should not be in competition with funds for internal government responsibilities.

Likewise, I would not disturb the Department of Health, Education, and Welfare, which is now functioning successfully in the life sciences. Although the National Astronautics and Space Agency and the Atomic Energy Commission are operating agencies in the same sense as the agencies in category (iii), their size and specialized functions are such as to justify their independence. It would seem unwise to upset their successful operations for the doubtful advantage of operational symmetry. If combined into a new department, these two agencies would bury the very functions that the new department should be designed to expand and develop. The purpose of the new department should be to correct deficiencies and not simply to engage in organizational exercises.

The most impelling argument that has been advanced against such reorganization of science in government is that Congress is in no mood to stop with the kind of measures that I have proposed. There is real fear that in organizing a Department of Science and Technology Congress would end up by dumping all the scientific activity of the departments

and agencies into such a department. An indiscriminate lumping together of all categories of government activity in science would, of course, be little short of catastrophic. The damage so done would doubtless outweigh, by far, the advantages to be achieved. Because of this very fear, I believe, scientists generally have not advocated, or have even opposed, the creation of a Department of Science and Technology.

Executive Responsibility

Consequently, any initiative for corrective action should originate in the executive branch of our government, where a carefully prepared and well-reasoned plan can be presented to Congress. Failure of the executive branch to review broad deficiencies in federal scientific and technological activity has arisen from lack, until recently, of any workable mechanism for examining and formulating technological and scientific policy at the top governmental level. Of course, such a charge was assigned by Congress to the National Science Foundation. But from my earlier analysis of government responsibilities in science it may be readily seen that, organizationally, it is quite impossible for the foundation to assume or to discharge this responsibility successfully. Since the foundation discharges one of the three coequal functions of federal science and technology, it cannot coordinate all three without endangering that function for which it is principally responsible.

For this reason, the President's science adviser and the Science Advisory Committee have a major role in the examination and formulation of over-all broad policy for federal science and technology. I visualize their duties along the following lines: (i) to assess the impact of science on government, in all its aspects, military, economic, and social; (ii) to evaluate the balance of the United States program of science and research in order to insure adequate support for all areas of scientific research; (iii) to be especially sensitive to new potentialities for scientific research and development, and to find means to open up, and to recommend support for, new areas of activity; (iv) to review adequacy of support for reconstruction and extension of facilities for scientific research to keep America's research plant up to date, with the objective of creating a plant capable of investigating the clues that nature provides, to the full extent possible with the tools that can be provided by our technology (our research plant is now seriously obsolescent); (v) to review constantly the character of the opportunity offered scientists and engineers and the administration of scientists and engineers within government, looking to the improvement of government personnel practices with respect to such men; (vi) to insure suitable and adequate federal practices in support of scientific information; (vii) to monitor federal policies on international collaboration in science; and (viii) to review, from time to time, the effectiveness of broad federal policies with respect to the general health of scientific research.

In these tasks the President's Science Advisory Committee might well lean heavily on the National Academy of Sciences. The academy is representative of our most skilled scientific workers. In its statutory function of advising government the academy should be an especially valuable source of advice on explicit questions that the committee may properly ask it.

But, of course, neither the committee nor the academy has the facilities for the detailed planning and preparation of data that are prerequisite to discharge of their policy responsibilities. Moreover, there are subfunctions of policy planning that are intimately associated with departmental functions which can never be carried adequately by any external committee. Consequently, the new Federal Council for Science and Technology, chaired by the President's science adviser, assumes a major role in policy planning.

With the President's Science Advisory Committee for broad policy function and with the federal research council for policy planning, the President's science adviser should find adequate means of formulating both broad and detailed policy. These are the policy tools needed by the executive branch to plan a Department of Science and Technology and to guide it through congressional debate in suitable form. I believe that with these tools, the nation can safely undertake the corrective action required by the present grave deficiencies in federal science and technology through organization of a Department of Science and Technology, without danger of creating a governmental monstrosity that would wreck the direction of federal scientific effort. We can now regroup related federal responsibilities in science and technology from haphazard into workable form.

To achieve these ends demands that a sobering and challenging measure of responsibility be assumed at every level of social and political action.

Role of the Biological Station

It can bring field problems into the laboratory and test laboratory problems in the field.

Stanley A. Cain

To simplify the question I have posed for myself—What is the role of the biological station?—I would exclude from present consideration agricultural, forestry, medical, and other experiment stations that are concerned largely with problems of immediate practical importance in restricted fields and have a permanent staff of investigators. Such experiment stations are also largely governmental institutions. I would exclude, as special cases, Brookhaven, Oak Ridge, and other installations of the Atomic Energy Commission, the Navy's Point Barrow station, and similar installations. The private research stations of pharmaceutical firms and other business enterprises form another special category, as do Audubon and other natural history field schools. Finally, I would omit from present consideration college wild-land preserves and similar reservations that are without attached laboratory and related physical facilities.

All such institutions may be the sites of fundamental biological research, and many of them carry on some of the functions of biological stations. These omissions still leave us with a great number and variety of institutions and operations that generally are recognized as biological stations even though the distinction between them and those omitted may not be sharp.

What can one say of the role of biological stations when they are so varied? Many are marine or fresh-water stations, while others are largely terrestrial in activity and may be located in mountains or on continental plains. Some are large and wealthy, but others are small, ill-equipped, and struggling. A few oceanographic stations have ocean-going yachts that cost $1000 a day to operate, while others are limited in range by having only rowboats or, at best, a small diesel launch. Some biological stations are specialized, dealing, for example, only with problems of fisheries or with seaweeds, but most have a range of activity as broad as the field of biology itself. Many are local or regional in interest while others, such as the Woods Hole Oceanographic Institute, are concerned with the wide sweep of the oceans.

The author is professor of conservation and chairman of the department of conservation of the School of Natural Resources, University of Michigan, Ann Arbor. This article is adapted from an address delivered 27 June 1958 at the dedication of the Highlands Biological Station, Highlands, N.C.

Common Characteristics

Biological stations have certain characteristics in common. Although closely tied in most cases to higher education, they are physically separate from the campuses of the universities and colleges which sponsor or utilize them and are usually located where the biota is rich and varied and where nature is comparatively unspoiled.

A second characteristic of biological stations results from the kinds of research usually carried out there and the kinds of teaching they offer. Although studies made at biological stations may be in morphology and anatomy, physiology, biochemistry, biophysics, and genetics, such studies might as well be carried out at the usual campus and urban laboratory (except for the more pleasant environment of the station) unless they exploit the abundance of living material close at hand and the natural terrestrial and aquatic habitats. One thinks of the biological station as traditionally and predominantly a center for taxonomic and ecological studies.

All biological stations, I believe, are involved in research. Some have a fairly large research staff, but this is augmented, as are the staffs of the seasonal stations, by professors on leave from other institutions, investigators assigned from government or industry on special projects, and others taking advantage of summer vacations to make studies without the distractions of students and administrative duties. A most important characteristic of biological stations, it seems to me, is the large extent to which the investigator is free to follow his own bent and to choose from among many opportunities. If the station has well-equipped laboratories and is well situated for field work, the array of possibilities for study and research greatly surpasses that of the campus laboratory.

Most biological stations are involved in teaching, at least in the sense of supervised research, and some of them offer regular classes in upper-division and graduate-level subjects. However, I do not know of any large biological station that is devoted solely to teaching (although the Wyoming Science Field School approaches it in geology and biology), and I know of none that is managed principally for the teaching of beginning subjects in biology.

I think that one prime virtue of the biological station is that it is the natural meeting place of the general and the specific, the qualitative and the quantitative, the descriptive and the experimental. It is the place where field problems can be brought into the laboratory for refinement and where laboratory problems can be tested in the field. The door of the biological laboratory swings both ways. A further important feature of biological stations, in contrast to the usual campus situation where inter- and intradepartmental fences are high, is the close commingling of specialists of different breed under conditions in which they are likely to interact. The easily acquired knowledge of another's problems and results is stimulating and broadening and often leads to cooperation and joint research.

Qualitative and Quantitative Approach

In order further to examine the role of the biological station, I wish to make some remarks about the roles of qualitative and quantitative science. All branches of science tend to change from a qualitative to a quantitative approach as they undergo development.

The quantitative approach was attained earlier in the physical than in the biological sciences. Among the biological

sciences a quantitative approach developed earliest in physiology and has been carried farthest, perhaps, in biochemistry and biophysics. Genetics was early forced into mathematics and soon developed its Sewall Wrights, whose mathematics is sometimes too esoteric for most biologists. Taxonomy, of course, long has counted and measured organs of plants and animals in its descriptive morphology and has only recently turned to refined biometric analysis of populations and the statistical separation of races, subspecies, and species. Ecology and biogeography started as broadly descriptive sciences with a large intuitive element, especially as to communities for which biotic composition was emphasized over structure. To a considerable extent ecology is still largely nonquantitative. More lately, concern with the nature and causes of physiognomic similarities and differences among communities is leading to quantitative plant ecology, with emphasis on the number, arrangement, and form of constituent organisms as aspects of structure. Appropriate new methodologies, largely statistical, are only partly developed and occasionally applied by ecologists. Both in systematics and in ecology the recent concern for quantification, coupled with the size and complexity of many populations and communities, is leading investigators to consideration of the statistical requirements of sampling.

Grieg-Smith, in his new *Quantitative Plant Ecology* (*1*), points out a basic difference between the physical and the biological sciences. In the physical sciences it is generally possible to isolate for study one variable at a time, but in the biological sciences this is rarely possible. The quantitative approach, as a consequence, is usually much more difficult in biology than in the physical sciences. In the physical sciences differences among replicated measurements often are due to methodology; hence, with refinements in instrumentation and methods, sets of measurements can be obtained that have very slight variability. In biology differences among replicated measurements are due not only to deficiencies in techniques, as in the physical sciences, but also to fluctuations in variables not being studied that are thought or assumed to be constant.

Biologists may use clonal materials or pure lines in control chambers or phytotrons, or in field tests, and assume that variability has been eliminated for hereditary and some environmental factors when, in reality, it has not been eliminated and its effects remain to confuse the biological characteristic being examined; this sometimes results in wide differences among measurements or replicated material. For example, recent studies on peas by Frits Went and his associates, made in the phytotron at the California Institute of Technology, indicate that the past environmental history of certain plants influences their responses to various environments. Both the growth characteristics and the temperature optimum of a given strain of peas are dependent not only on the conditions during growth but on the past history of that strain through several generations. This is similar to the findings by Sonneborn that within a single genetic strain of *Paramecium aurelia* there can exist a number of distinct nongenetic forms dependent on the environment of culture. Whether or not this is a sort of mid–20th-century Lamarckianism, these "enduring modifications" represent at least a temporary inheritance of a nongenetic nature. They suggest also one of the reasons why biological replications may result in considerable variability among measurements.

The familiar difficulty in biology of obtaining truly replicate samples led one biologist—more frank and verbal than most—to what he called a new law: No matter how rigorously you control your experiments, organisms do as they damned well please.

Education and Training

However important biological stations are for the pursuit of research by mature and experienced investigators, I believe one of their most important roles—perhaps I should say opportunities—is in education and training.

Biological education might well start where biology did—with an interest in the recognition and classification of species and in their local and general places of occurrence, together with an interest in their usefulness to man. This would be followed by an interest in their relationships and development—their development as individual organisms and their evolution. This is natural history—a knowledge of life in nature. It presupposes a love of nature as well as a love of knowledge. From such a base of intimate but general experience one can move on to whatever refined techniques, precise measurements, and specialization interest demands and the correlative advances of other sciences permit.

There is a reciprocal dependency here. The field biologist will encounter problems he can't solve without recourse to quantification and, in many cases, to the laboratory and the methodologies of physiology or genetics. Contrariwise, the laboratory man may be working not with the realities of nature but with the artifacts of the control chamber, the decimated organism, and the dying cell.

We can all think of examples of the incomplete biologist. I know of a doctoral thesis on the anatomy of the apical meristems of three members of a fern genus common throughout the eastern United States done on pickled material drawn from bottles on the shelf by a man who was said never to have seen these beautiful plants growing naturally. A widely known mistake that has caused many smiles was made by an investigator of seed dormancy at a well-known research institute. He found out a lot about the physiology of the seeds of the tropical American papaw, *Carica papaya,* and published it. Unfortunately, in view of his later embarrassment, he looked up *papaw* in Gray's *Manual* and attributed his work to the temperate American *Asimina triloba,* a very different plant.

To be fair about this telling of anecdotes, I should mention the field ecologist, intrigued by a new gadget permitting rapid, accurate field measurements of soil acidity, who averaged *p*H numbers arithmetically, although a beginner in chemistry would have known that the numbers are powers of the hydrogen ion concentration and can't be added and averaged directly. And, of course, many ecologists have embarrassed themselves by assuming a correlation between structure and function when no epharmonic relationship existed. Schimper's hypothesis of physiological drought of bog plants stood unchallenged for decades and spawned some ingenious hypotheses in explanation of "xerophytes" growing in water until Walter, Stocker, and others finally experimented with these plants and showed that, although they looked like xerophytes, they were only xeromorphic and actually used water as freely as mesophytes and in some cases were profligate with it.

You probably have anticipated my reason for making such remarks. I believe in the marriage of field and laboratory approaches, and in the existence of at least two roads to biological truth: the observations of the astute naturalist in uncontrolled field conditions and the measurements—as precise as possible under conditions as controlled as possible

—made by the laboratory investigator.

Where better can a student learn the value of, and respect for, the two sides of the biological coin than at a biological station? Where better can the investigator move his field problem into the laboratory or his laboratory problem into the field than at a biological station? At a biological station the physiologist may stick to his test tubes and the ecologist to his quadrats, but in the close camaraderie of the biological station both are likely to get contaminated or (perhaps a better biological figure of speech) cross-fertilized, with resultant intellectual heterosis.

I would suggest, then, that the training and experience of a biologist should repeat in essential outline the history of the development of biology as a general science, and that his specialized education should repeat the history of the specialty. I will restate that by paraphrasing a familiar biological principle: The intellectual ontogeny of the biologist should recapitulate the intellectual phylogeny of biology. I am not sure that my pedagogical principle would be acceptable to the professional educators, but I believe that it is in line with the human being's natural course of development. I feel certain that many promising young biologists, who started perhaps as collectors of insects, shells, or bird lists, have been discouraged from following their inclinations by the stultifying effects of their early experience with general zoology and, later, anatomy designed for premedical students. And many potential botanists, who were taught with the heavy hand of Germanic ordination about a world of organisms unknown to the student and long embalmed in formaldehyde and strapped to herbarium sheets, have turned their backs forever on plant science.

Starting with a broad base in natural history, the future biologist can develop in whatever direction his maturing interests dictate without ever losing either his perspective or his enthusiasm.

My only general criticism of the situation with respect to biological stations is that nearly all of them are designed to meet the needs of the trained investigator and, at most, of the advanced student. It is not that these are unimportant or dispensable functions, but that there should also be some biological stations for senior high-school and lower-division college students where they can be as scientific as they will but where it is also respectable to behave like Carolus Linnaeus, Thomas Say, or any other "father of biology."

I have completed my brief for the biological station, and it is, of course, a familiar one. But as Seneca long ago said, "A thing is never too often repeated which is never sufficiently learned."

Balanced Program in Science

These considerations of the characteristics of biological stations and the opportunities they offer for the progress of biology, together with my belief that biologists develop naturally very much along the general lines of the development of biological science, lead me to the conclusion that we do not have in this country the full array of biological stations that we need. Most stations are designed, equipped, and managed to promote advanced investigation, and most teaching at them is correlative with the spirit of research in the areas that lend themselves to control and quantification. Many old stations have, through the years, dropped or minimized field-based taxonomic and ecological work. I would not call for any reduction in the programs of such stations but would, on the contrary, welcome increased support for them, especially where the costs are large relative to traditional biology. The need for large expenditures in astronomy, geophysics, physics, chemistry, and geology has been better sold than has the need in biology, except, perhaps, in medicine and some applied fields. In comparison we have, I believe, far too few biological stations that devote themselves mainly and without apology to such fields as taxonomy and ecology.

Yet I would strongly express my belief that we very much need at least some biological stations devoted to beginning experiences in biology for young people, perhaps in the range of the last two years of high school and the first two years of college. It seems to me that at present our talent searches, systems of recognition and award, and facilities—in fact, our national concern—for young people in science is too much directed toward the physical sciences and mathematics. Without reduction in such worthy efforts, let us urge the development of the life sciences and their application so that we may have a more healthy, rational, and balanced program in science and in the popular appreciation of science.

Reference

1. P. Greig-Smith, *Quantitative Plant Ecology* (Academic Press, New York, and Butterworths, London, 1957).

News of Science

Where Is Peking Man? Anthropologists Are Still Speculating about the War-Lost Specimens.

The whereabouts of "Peking man," the world-famous anthropological collection that disappeared during World War II, is still the subject of hopeful speculation. Composed of specimens that are among the earliest traces of mankind, the collection was excavated from the floor of a limestone cave at Choukoutien, about 40 miles southwest of Peking, China, between 1928 and 1937.

Peking man is believed to have lived in eastern China during the Middle Pleistocene, some 300,000 years ago. By 1929, the skeletal remains recovered had definitely established him as a new type of fossil man, which was named *Sinanthropus pekinensis*. In 1937, the individuals represented in the *Sinanthropus* collection numbered approximately 38. Braincases, jaws, teeth, and some limb bones were included. Cutting and scraping implements, made chiefly of quartz, were found with the bones.

Peking Man Disappears

According to the best information available, the remains of Peking man escaped the first onrush of the Japanese forces in North China in 1937 because they were stored in an American institution, the Peking Union Medical College. An agreement had been reached with the Chinese that the *Sinanthropus* material should remain in China permanently, and there be available to scholars of all nations for study. A few weeks before the United States became involved in World War II, negotiations were completed with Chungking for shipping the specimens to the United States for the duration. Peking man and all other associated specimens were packed in three cases and turned over to the U.S. Marines, who were being evacuated from Chinwangtao on the American Dollar liner *President Harrison*. On 8 December 1941, the liner was run aground in the Yangtze Kiang River near Shanghai, and the Marines were captured, and with them the three cases of *Sinanthropus* material. From that point on there is no definite knowledge about what happened to the remains.

Frank Whitmore, chief of the Military Geology Branch, U.S. Geological Survey, has been accused many times during the past decade of knowing more than he would tell about the whereabouts of *Sinanthropus*. Recently, he reaffirmed an earlier statement that denied any secret knowledge. He believes, as do many others, that the collection is at the bottom of the Yangtze.

Postwar Search

In 1942, the Japanese anthropologist Haseba Kotohito went to Peking to study *Sinanthropus*; but when the vaults at the college were opened, only plaster casts were found. A year later, Japanese police made a thorough search, questioning everyone known to have had any connection with the collection, but all to no avail.

Among those associated with the recovery of the *Sinanthropus* material were the late Davidson Black, anatomist of Peking Union Medical College, who started the excavations that led to the discovery of Peking man; the late Franz Weidenreich, another anatomist, who succeeded Black at Peking; Ralph W. Chaney, paleobotanist of the Carnegie Institution of Washington and the University of California at Berkeley; and Pei Wen-chung, Chinese paleontologist. According to Pei, the missing packing cases went to Tokyo and some day will reappear there.

In 1945, Whitmore was detailed from Headquarters, Supreme Commander Allied Powers, to examine "certain fossils and archaeological material from Choukoutien, China" at Tokyo University. However, most of the material that he was shown was from the upper Choukoutien cave, belonging to an age much younger than that of *Sinanthropus*. In a statement about these specimens, Whitmore says in part:

"Most of the material recovered was from the Upper Cave, which is much younger than the strata in which *Sinanthropus* was found. There are a few stone implements of questionable nature from Locality 15, which is probably Paleolithic and is older than the Upper Cave material. From Locality 1, which includes the strata in which *Sinanthropus* was found, there are only three questionable stone implements and no bone remains. This material was returned to the Cenozoic Laboratory (in Peking) in early 1946. Nothing was learned of the fate of the missing *Sinanthropus* specimens."

According to Whitmore, the best hope for restoring Peking man to anthropologists at firsthand lies in a resumption of excavations at Choukoutien cave. Although excellent plaster casts of the skeletal material are available, these obviously do not have the same value for researchers as the original specimens.

International Oceanographic Congress

The AAAS, in cooperation with UNESCO and the Special Committee on Oceanic Research of the International Council of Scientific Unions, is organizing an International Oceanographic Congress to be held from 1 August to 12 September at the United Nations Building, New York.

Abstracts and Manuscripts

As many more abstracts have been received than were anticipated, a change has been made in the requirement that manuscripts be submitted on 30 April. It is now requested that a 500-word summary in English, with a 200-word abstract in another language of the congress (French, German, Russian, or Spanish), be prepared for submission on that date.

Three copies of summary and abstract must be sent to: Dr. Mary Sears, Chairman, Committee on Arrangements, International Oceanographic Congress, c/o Woods Hole Oceanographic Institution, Woods Hole, Mass. If these materials are not received by the 30 April deadline, they cannot be included in the bound, multilithed volume to be issued to registrants.

It will no longer be necessary to submit a completed paper unless the convener of the seminar specifically requests that this be done. Some seminars will be organized in the conventional way, with presentation of a series of papers followed by a discussion period. Others—those that have a relatively small number of participants—will be arranged so that the completed papers are circulated among the participants in advance. In these sessions, the proceedings will be confined to a discussion of the papers.

It is hoped that the participants within the United States may be able to arrange for any duplication needed for the "discussion-type" seminar. Because of diffi-

culties in shipment of manuscripts in bulk from abroad, arrangements will probably have to be made for duplication of such manuscripts in the United States. Details for this will be arranged by the individual conveners.

Exhibits

There will probably be no difficulty in setting up nonprofit exhibits that consist of panels and shallow display materials. It is expected that these can be placed along the approaches to the session rooms, in corners, and so forth, at the United Nations Building. The U.N. and the AAAS cannot be responsible for any equipment, instruments, and other materials associated with these exhibits. Each exhibitor will be responsible for erecting and dismantling his exhibit.

However, the association will be glad to advise on shipping arrangements, sources of labor, location of exhibits, and so forth. Anyone desiring to make such arrangements should write to: Dr. Raymond L. Taylor, American Association for the Advancement of Science, 1515 Massachusetts Ave., NW, Washington 5, D.C. A carbon copy of the request should be sent for informational purposes to Dr. Sears.

It is likely that films, either technical or semipopular, which do not illustrate a particular paper, will be shown at the Hotel Commodore in the evenings, probably during the first week.

Registration and Accommodations

Registration will start on Sunday, 30 August, at 10 A.M. at the Hotel Commodore, Lexington Avenue and 42nd Street. The Commodore will be the hotel headquarters of the AAAS. All those who wish to attend any sessions of the congress must register there on arrival, even if late.

There will be a registration fee of $10 that will entitle the registrant to receive (i) a badge that will serve as an entrance pass at the United Nations Building; (ii) a copy of a volume that will contain summaries of all papers being presented at the afternoon seminars; (iii) invitations to social events; and (iv) information on points of interest in New York City.

A block of rooms has been reserved at reduced rates at the Hotel Commodore for those wishing to attend the congress. Rates for single rooms will be $8, $9, and $10 per night; for double rooms (with two beds), $13, $14, and $15 per night. All room prices are subject to an additional 5-percent New York City room tax. The hotel will make reservations for each person on receipt of his or her request. The Hotel Commodore is the only hotel where the AAAS has arranged for special rates, and it is hoped that most participants will stay there.

The AAAS cannot be responsible for making individual hotel reservations. Anyone who wishes more modest quarters should arrange for these through a local travel agent. The association cautions that reservations should be made well in advance, no matter where one plans to stay. If no reservation has been made before the congress opens, the association will assist in locating suitable quarters. It can, however, give no assurance that any will be available.

Program

A program of morning lectures and afternoon seminars has been prepared. The morning lecture series, which are grouped around several broad topics, will be in sequence and are designed to interest all oceanographers. Originally, it was planned that the three afternoon seminars, held simultaneously, would be based on the general theme of the three lectures delivered that same morning. However, as the conveners' plans for the seminars developed, it became clear that this was impractical. The new schedule makes it possible for each participant to attend nearly all seminars in closely related fields. There may still have to be slight modification, such as the addition of extra sessions for certain seminars and, possibly, of a few general sessions for papers on topics that do not fit within the scope of the seminars.

Morning Lecture Series

31 Aug. "History of the Oceans," AAAS Committee representative, Roger Revelle (Scripps Institution of Oceanography, University of California); chairman, G. E. R. Deacon (National Institute of Oceanography, Great Britain). "Shape and structure of ocean basins," W. Maurice Ewing (Lamont Geological Observatory, Columbia University); "Forces and processes at work in ocean basins," Edward C. Bullard (Cambridge University, Great Britain); "Stratigraphy of the deep sea," Edwin L. Hamilton (U.S. Navy Electronics Laboratory, San Diego, Calif.).

1 Sept. "History of the Oceans" (continued), chairman, Haakon Mosby (Geofysisk Institut, Universitet i Bergen, Norway). "History of sea water," G. E. Hutchinson (Yale University); "Origin of life in the ocean," A. I. Oparin (A. N. Bach Institute of Biochemistry, Academy of Sciences, U.S.S.R.); "The marine climate record," Gustaf O.S. Arrhenius (Scripps Institution of Oceanography).

2 Sept. "Populations of the Sea," AAAS Committee representative, George Myers (Stanford University), and Lionel A. Walford (U.S. Fish and Wildlife Service); chairman, Enrico Tortonese (Museo Civico di Storia Naturale, Genoa, Italy). "Paleobiogeography," Preston E. Cloud (U.S. Geological Survey); "Biogeographical boundaries—the shapes of distribution," R. S. Glover (Oceanographic Laboratory, Edinburgh, Scotland); "Evolution in the deep sea," G. S. Carter (Cambridge University, Great Britain).

3 Sept. "Populations of the Sea" (continued), chairman, N. K. Panikkar (Central Marine Fisheries Research Station, India). "The role of ethology in oceanography," H. O. Bull (Dove Marine Laboratory, Great Britain); "Physiology of marine organisms in relation to their environment," H. Friedrich (Institut für Meeresforschung, Bremerhaven, Germany); "Cultivation of marine organisms as a means of understanding environmental influences on populations," Trygve Braarud (Oslo University, Norway).

4 Sept. "The Deep Sea," AAAS Committee representative, Henry M. Stommel (Woods Hole Oceanographic Institution); chairman, Georg Wüst (University of Kiel, Germany). "Geochemistry and physics of circulation," Harmon Craig (Scripps Institution of Oceanography); "Special quantitative characteristics of the ocean bathypelagic and bottom life," L. A. Zenkevich (Institute of Oceanology, Academy of Sciences, U.S.S.R.); "Turbulent transports," Willem V. R. Malkus (Woods Hole Oceanographic Institution).

7 Sept. "The Deep Sea" (continued), AAAS Committee representative, Gustaf O.S. Arrhenius (Scripps Institution of Oceanography, University of California); chairman, Carl W. Correns (Göttingen University, Germany). "Distribution of pelagic sediments (biological and inorganic components)," M. N. Bramlette (Scripps Institution of Oceanography); "Nuclear processes in pelagic sedimentation," E. Picciotto (Belgium); "Abyssal benthic organisms; nature, origin, distribution and influence on sedimentation," A. Fr. Bruun (University Zoological Museum, Copenhagen, Denmark).

8 Sept. "Boundaries of the Sea," AAAS Committee representative, Gordon G. Lill (Office of Naval Research, Washington, D.C.); chairman, J. N. Carruthers (National Institute of Oceanography, Great Britain). "Coupling of sea and air," P. Welander (Meteorological Institute, Stockholm, Sweden); "Spectrum of sea level," Walter H. Munk (Scripps Institution of Oceanography); "Problems of epicontinental sedimentation," Ph. H. Kuenen (Geological Institute, Groningen, Holland).

9 Sept. "Boundaries of the Sea" (continued), chairman, B. Kullenberg (Oceanografisk Institut, Göteborg, Sweden). "An estuarine model of the subarctic Pacific Ocean," John P. Tully (Pacific Biological Station, Nanaimo, B.C., Canada); "The length of pelagic

larval life in marine bottom invertebrates as related to larval transports and ocean currents," Gunnar Thorson (University Zoological Museum, Copenhagen, Denmark); "Surface films and their importance in exchange processes."

10 Sept. "Cycles of Organic and Inorganic Substances in the Ocean," AAAS Committee representative, Fritz F. Koczy (University of Miami); chairman, Y. Miyake (Central Meteorological Observatory, Tokyo). "Physical chemistry of sea water," Lars Gunnar Sillen (Royal Institute of Technology, Stockholm, Sweden); "Biologically active substances," C. E. Lucas (Marine Laboratory, Aberdeen, Scotland); "Primary production," J. H. Steele (Marine Laboratory, Aberdeen, Scotland); "Balance between living and dead matter in the oceans," W. D. McElroy (Johns Hopkins University).

11 Sept. "Cycles of Organic and Inorganic Substances in the Ocean" (continued), chairman, Thomas G. Thompson (University of Washington, Seattle). "Air-ocean," Erik Eriksson (Meteorological Institute, Stockholm, Sweden); "Sea-water and sediment," S. W. Brujewicz (Institute of Oceanology, Academy of Sciences, U.S.S.R.); "Vertical and horizontal transport in the ocean," L. H. N. Cooper (Marine Biological Association, Plymouth, Great Britain).

Afternoon Seminars

31 Aug. "Shape and structure of the ocean basins and the forces involved," conveners, Maurice N. Hill (Cambridge University, Great Britain) and Harry H. Hess (Princeton University); "Physical chemistry of sea water and surface films," conveners, Dayton E. Carritt (Chesapeake Bay Institute, Johns Hopkins University) and Gifford C. Ewing (Scripps Institution of Oceanography); "Biogeography and environmental influences," convener, Joel W. Hedgpeth (Pacific Marine Station, Dillon Beach, Calif.).

1 Sept. "Shape and structure of the ocean basins and the forces involved" (continued); "Physical chemistry of sea water and surface films" (continued); "Bathypelagic organisms," conveners, A. Fr. Bruun and Torben Wolff (University Zoological Museum, Copenhagen, Denmark).

2 Sept. "History of sea water and the origin of life," convener, William W. Rubey (U.S. Geological Survey); "The influence of land masses on the distribution of organisms," convener, K. O. Emery (University of Southern California); "The role of ethology in oceanography," conveners, H. O. Bull (Dove Marine Laboratory, Great Britain) and T. J. Walker (Scripps Institution of Oceanography).

3 Sept. "History of sea water and the origin of life" (continued); "Epicontinental sediments and nearshore sedimentary processes," convener, Robert S. Dietz (U.S. Navy Electronics Laboratory, San Diego, Calif.); "Primary production," convener, John H. Ryther (Woods Hole Oceanographic Institution).

4 Sept. "Stratigraphy of the deep sea and the marine climate record," conveners, Cesare Emiliani (University of Miami) and William R. Riedel (Scripps Institution of Oceanography); "Turbulent transports," convener, Willem V. R. Malkus (Woods Hole Oceanographic Institution); "Cultivation of marine organisms as a means of understanding environmental influences on populations," convener, Dixy Lee Ray (University of Washington, Seattle).

7 Sept. "Stratigraphy of the deep sea and the marine climate record" (continued); "Deep sea circulation," convener, Charles S. Cox (Scripps Institution of Oceanography); "Physiology of marine organisms in relation to their environment," convener, Otto Kinne (University of Toronto, Canada).

8 Sept. "Physical and biological processes in sedimentation," convener, E. L. Hamilton (U.S. Navy Electronics Laboratory, San Diego, Calif.); "Nutrient relationships," convener, Bostwick H. Ketchum (Woods Hole Oceanographic Institution); "Evolution and adaptation in the sea," convener, A. A. Buzzati-Traverso (Universita di Pavia, Italy).

9 Sept. "Physical and biological processes in sedimentation" (continued); "Estuarine and nearshore circulation," convener, D. W. Pritchard (Chesapeake Bay Institute, Johns Hopkins University); "Paleobiogeography," convener, Preston E. Cloud (U.S. Geological Survey).

10 Sept. "Nuclear processes in marine sedimentation," Johannes Geiss (University of Miami); "Sea-air interchange," convener, Erik Eriksson (Meteorological Institute, Stockholm, Sweden) and Bernhard Haurwitz (High Altitude Observatory, Boulder, Colo.); "Biologically active substances," convener, Luigi Provosoli (Haskins Laboratories, New York).

11 Sept. "Sea water sediment exchange: marine minerals," convener, Edward D. Goldberg (Scripps Institution of Oceanography); "Spectrum of sea level," convener, Walter H. Munk (Scripps Institution of Oceanography); "Balance between living and dead matter in the oceans," convener, Eugene Corcoran (University of Miami).

New Atomic Particle

The discovery of an atomic particle, the xi zero or neutral cascade hyperon, has been announced by a group of scientists at the University of California's Lawrence Radiation Laboratory and by the Atomic Energy Commission. The discovery is unique in that it was dependent upon observation of two interconnected invisible "tracks" between sets of visible tracks in a photograph. Analysis of single invisible tracks has been common.

The particle completes the list of predicted particles of ordinary matter. A few predicted antiparticles remain to be seen.

The report on the xi zero appears in the current issue of *Physical Review Letters*, a publication of the American Physical Society, by the following group of researchers: Luis W. Alvarez, professor of physics at the University of California; Philippe Eberhard, physicist on leave from the Centre National de la Recherche Scientifique de France; Myron L. Good, physicist at the Lawrence Laboratory; William Graziano, graduate student; Harold K. Ticho, professor of physics, University of California, Los Angeles; and Stanley G. Wojcicki, graduate student.

The particle was discovered by means of the laboratory's 15-inch liquid hydrogen bubble chamber, which was exposed to a special beam of particles produced by the Lawrence laboratory's bevatron.

The particle has a mass about 40 percent greater than the proton. It has no electrical charge. Its lifetime is fleeting —about one ten-billionth of a second.

The investigators found only one photograph with evidence of the creation of the xi zero. This photograph was taken just before Christmas. It was one of 70,000 taken during an experimental run extending over a period of several weeks.

United States-EURATOM Program

The U.S. Atomic Energy Commission and the Commission of the European Atomic Energy Community have announced that the U.S.-EURATOM Joint Research and Development Board will begin meeting early in April to consider proposals under the U.S.-EURATOM Joint Research and Development Program. Proposals are to be submitted in response to the invitation issued by the AEC and EURATOM in December 1958.

The research and development program is centered on nuclear power reactors and is an integral part of the joint program contemplated by the Agreement for Cooperation between the United States and EURATOM that came into effect on 18 February. The over-all industrial objective is "to bring into operation within the European Atomic Energy Community (EURA-

TOM) large-scale power plants using nuclear reactors of types on which research and development have been carried to an advanced stage in the United States, having a total installed capacity of approximately one million kilowatts of electricity, by December 31, 1963 (except that two reactors may be selected to be in operation by December 31, 1965), and under conditions which would approach the competitive range of conventional energy costs in Europe."

No specific deadline for the submission of proposals is being established in this continuing program; however, those proposals which are on hand by 1 April will receive early consideration by the joint board. The guide for submission of proposals may be obtained by writing to the EURATOM-U.S. Joint Research and Development Board, 51 Rue Belliard, Brussels, Belgium, or to the Director, Division of International Affairs, U.S. Atomic Energy Commission, Washington 25, D.C.

Pioneer IV

At 11:30 A.M., Friday, 6 March, Pioneer IV, America's first artificial asteroid, sent its last message to earth. It had by then reached a distance of more than 410,000 miles from the earth and was traveling at a speed of almost 4000 miles an hour into an orbit around the sun.

Before the mercury batteries went dead, the asteroid had established a long-distance record for communication, after a lifetime of more than 83 hours. The Soviet Union said it had tracked its Mechta space probe—now in orbit round the sun—to a distance of 370,000 miles before the batteries became exhausted, after 62 hours of flight.

At perihelion, its closest approach to the sun, which it reached on 17 March, Pioneer IV was 91.7 million miles from the sun, or 1.2 million miles inside the earth's orbit. At aphelion, its farthest point from the sun, it will be 106.1 million miles from the sun, or 13.2 million miles outside the earth's orbit. It will reach that point on 29 September. It will circle the sun every 394¾ days, traveling in its orbit at an average speed of 60,000 miles an hour, as compared with the 66,000-mile average for the orbital speed of the earth.

Pioneer IV is expected to produce more scientific information than Mechta. From Pioneer's radio, NASA personnel got information about temperatures, radiation, and cosmic rays. NASA scientists said that, according to information already evaluated, no major band of radiation has been encountered above the two previously discovered by the United States' Explorer satellites.

Congress Asked for Larger Science Budget

Alan T. Waterman, director of the National Science Foundation, has strongly protested the Administration's reduction of the foundation's budget and has suggested, further, that the present $280-million level of government support for basic research be increased by about 50 percent. In testimony presented on 12 March before the House Select Committee on Astronautics and Space Exploration, Waterman reported that the NSF budget for the coming fiscal year had been cut from the $206 million that had been requested to $160 million. Most of the $46-million reduction was in the programs for support of basic research and for construction of new research facilities.

Pointing out that universities and nonprofit research institutions could no longer afford to modernize or replace their facilities, Waterman said that some laboratories "have become obsolescent to a point which is detrimental to the country's research effort." He then described a number of the foundation's programs that would have to be sharply curtailed, or eliminated completely, if more funds were not provided. Included was the program for building university nuclear research reactors and computer centers.

Test Detection Study

It has been reported that a panel of leading United States earthquake specialists, assembled by the Government to map a program aimed at foolproof detection of underground nuclear blasts, has recently completed its work.

The group met in secrecy. Its recommendations, now being transmitted to the White House, may not be made public for several weeks or months. The group, known as the Panel on Seismic Improvement, is an offshoot of President Eisenhower's Science Advisory Committee, headed by James R. Killian, Jr.

The task of the panel was to evaluate the most recent detection techniques and to report to the White House on an appropriate research program. Its recommendations may have a crucial bearing on the progress of the East-West talks in Geneva on the banning of nuclear arms tests. The negotiations appear deadlocked on the issue, among others, of inspecting regions where detection has suggested the possibility of a blast. The Soviet Union has charged that such inspection could be used to cloak espionage. The problem primarily concerns underground explosions, since it is difficult to distinguish between the shock waves of earthquakes and those produced by bomb blasts. Surface and aerial shots can be observed in a number of ways and with sufficient accuracy so that on-the-spot inspection is not essential. If an equally foolproof system could be devised for underground blasts, the Geneva log jam might be broken. However, such a system seems some time off.

Science Honor List

The University of Bridgeport, Bridgeport, Conn., will have a "Science Wall of Honor" in the Charles A. Dana Hall of Science that is now under construction. A roster of 25 names will be chosen, and suggestions are invited. Any individual in the world's history may be nominated, except that only those who have been deceased at least 10 years will be considered. Recognition in all instances will be limited to accomplishments in the fields of natural science—not in philosophy, history, or the social sciences.

To be considered, an individual must have made a fundamental discovery regarding the laws of nature or have been responsible for an invention not based on a previously known fundamental law of nature. The discoveries and inventions will be rated on their general value to mankind as well as on their contribution to man's knowledge. In most cases preference will be given to those who made discoveries, rather than to those who followed with practical applications.

After the selection of the original 25 names, one additional name may be added every year for 25 years until such time as there are a total of 50 names on the wall. At that time, only one name may be added every 5 years.

News Briefs

The World Health Organization has announced that World Health Day is scheduled for 7 April. Its theme this year will be "Mental Illness and Mental Health in the World of Today." Although generally more acute in countries of high economic development, mental illness is an international problem, one that no nation escapes. And it may become greater as the world level of industrialization and technology rises.

* * *

The Atomic Energy Commission has announced that the public is now permitted to participate in consideration of the safety aspects of all reactor projects in the commission's Power Demonstration Reactor Program. Heretofore, the public has had opportunity to take part in the review of safety aspects of only those reactors in the program that were

privately owned, and, therefore, subject to licensing by the commission. The new policy extends to the public the same opportunity with respect to reactors in the program that are commission-owned.

* * *

A behavioral science computer newsletter is being started as a department of the quarterly journal *Behavioral Science,* which is published by the Mental Health Research Institute of the University of Michigan. Behavioral scientists are making increasing use of high-speed computers in many novel ways, but there is a rather serious lack of communication among them, leading to duplication of effort. The newsletter, which will appear in April, has been established to help remedy this situation.

* * *

Seventeen more countries will participate in the Public Health Service's international research training program, Surgeon General Leroy E. Burney has announced. The program, started a year ago, provides medical research training in this country for scientists from abroad. With the 17 announced this month, 30 countries are now participating in the program.

The 17 new participants are: Argentina, Australia, Brazil, Ceylon, Chile, Colombia, El Salvador, India, Iran, Japan, Mexico, New Zealand, Pakistan, Peru, the Philippines, Thailand, and Uruguay.

* * *

Insect collections of the Smithsonian Institution have been enriched by more than 30,000 beetles gathered in El Salvador by O. L. Cartwright of the U.S. National Museum. The specimens consist chiefly of scarabs, which include some of the largest and most fantastic members of the class Insecta in their world-wide distribution and which are known in art as the Egyptian symbols of immortality. The El Salvador collection, which awaits systematic study, apparently contains no very unusual types but represents an area hitherto almost unrepresented in collections.

* * *

An 85-foot-diameter steel tracking antenna, capable of receiving radio signals from a distance in space of more than 400,000 miles, has provided a wealth of scientific data obtained from Pioneer IV. The antenna is located in a natural bowl-shaped area in a remote site on the Camp Irwin Armor Combat Training Center reservation of the U.S. Army near Goldstone Dry Lake in California.

The intricate unit is specifically designed for tracking and communicating with far-reaching space vehicles as part of this country's space exploration program. The initial range of 400,000 miles will be increased to 40 million miles in 1960, and 4 billion miles in 1962, by improving the efficiency of the "dish" as a receiver and by improving the power and size of space vehicle radio transmitters.

Grants, Fellowships, and Awards

Cardiovascular reporting. The American Heart Association has announced the seventh annual competition for the Howard W. Blakeslee Awards for outstanding reporting in the field of heart and blood vessel diseases. Selections will be made from among newspaper and magazine articles, books, radio and television programs, and films published or produced between 1 March 1958 and 28 February 1959. The deadline for entries is *1 May.* The number of winners to be selected will be determined by the judges. The awards carry an honorarium of $500 each. Entry blanks and rules folders may be obtained from local heart associations or from the American Heart Association, 44 E. 23 St., New York 10, N.Y.

Laboratory equipment. Scientists and science teachers in colleges, universities, and nonprofit organizations have been invited by the National Science Foundation to submit proposals for the construction of better laboratory equipment for use in the nation's schools. Under the terms of a new, experimental program, the foundation will consider proposals for the design and construction of improved laboratory equipment and for the development of new instructional materials for lecture demonstrations and for laboratory and field work for courses at elementary, secondary, and undergraduate college levels in mathematics, astronomy, earth sciences, physical and biological sciences, and engineering.

Proposals, signed by the project director and a responsible officer of the sponsoring college, university, or scientific organization, should clearly describe the work to be done, give the qualifications of the personnel involved, show how the proposed material will be evaluated and eventually made generally available, and present a detailed budget. Support under this program will not be provided for the purchase of equipment for refurnishing school and college laboratories or for commercial production of equipment or materials.

Because the new program is experimental in nature, funds are limited and grants will be relatively small. Although proposals may be submitted at any time, those to be considered for support during the current fiscal year should be sent *before 15 April* to the Course Content Improvement Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C.

Scientists in the News

LEONARD J. BRASS, associate curator, and HOBART M. VAN DEUSEN, assistant curator, of the department of mammals of the American Museum of Natural History left on 13 March on the sixth Archbold expedition to New Guinea. The main purpose of the trip, which will last at least 7 months, is to study the geographical and ecological relationships of the animal and plant life of the New Guinea and Australian area as a whole.

This series of expeditions is sponsored by Richard Archbold, research associate at the museum. The present trip is also being supported by a National Science Foundation grant to Brass, and by a grant to Van Deusen from the Explorers Club of New York.

The following scientists from the United Kingdom are now visiting the United States:

B. A. NEWTON, member of the Medical Research Council's Chemical Microbiology Research Unit, School of Biochemistry, Cambridge, England, arrived on 31 March to visit protozoological research centers in New York, Atlantic City (N.J.), Amherst (Mass.), Detroit, Chicago, Cleveland, Washington (11–18 May), Oak Ridge and Nashville (Tenn.), New Orleans, Houston, Los Angeles, San Francisco, and Montreal. He will leave the country on 10 July.

J. A. POPLE, superintendent, Basic Physics Division, National Physical Laboratory, Teddington, England, arrived on 31 March to attend a meeting of the American Physical Society (High Polymer Physics Division) Cambridge, Mass., and to attend some of the meetings of the American Chemical Society in Boston. His itinerary also includes Washington (7–12 and 20–23 April), Ottawa, Durham (N.C.), and New York. He will leave the country on 23 April.

KENNETH E. NEWLAND, director of the department of aviation at Stephens College, Columbia, Mo., has been appointed curator of the National Air Museum, Smithsonian Institution, Washington, D.C. He will take up his duties at the museum in June.

Twenty-five physicians, teachers, and research workers on the faculties of medical schools in the United States and Canada have been appointed Markle Scholars in Medical Science by the John and Mary R. Markle Foundation, New York. Each appointment carries with it a $30,000 grant, appropriated to the medical school where the scholar will teach and conduct research, to be used for 5 years for his support and to aid his

research. The 1959 Markle scholars are as follows:

BRUCE M. BRECKENRIDGE, instructor, pharmacology, Washington University School of Medicine (St. Louis).

CHARLES L. CHRISTIAN, instructor, internal medicine, Columbia University College of Physicians and Surgeons.

GEORGE O. CLIFFORD, assistant professor, internal medicine, Wayne State University College of Medicine.

N. JOEL EHRENKRANZ, assistant professor, internal medicine, University of Miami School of Medicine (Coral Gables).

CLIFFORD W. GURNEY, assistant professor, internal medicine, division of the biological sciences, University of Chicago.

ARTHUR HAUT, instructor, internal medicine, University of Utah College of Medicine.

CARL F. HINZ, JR., instructor, internal medicine, Western Reserve University School of Medicine.

MICHAEL HUME, instructor, surgery, Yale University School of Medicine.

GUY LEMIEUX, instructor, internal medicine, University of Montreal Faculty of Medicine (effective 1 July).

JEROLD F. LUCEY, assistant professor, pediatrics, University of Vermont College of Medicine (effective 1 July).

ERNEST E. McCOY, instructor, pediatrics, Vanderbilt University School of Medicine.

GERARD B. ODELL, instructor, pediatrics, Johns Hopkins University School of Medicine.

MARSHALL J. ORLOFF, assistant professor, surgery, University of Colorado School of Medicine.

SUYDAM OSTERHOUT, associate, internal medicine, Duke University School of Medicine.

BARRY PIERCE, assistant professor, pathology, University of Pittsburgh School of Medicine.

JOHN RANKIN, assistant professor, internal medicine, University of Wisconsin Medical School.

PHILIP N. SAWYER, instructor, surgery, State University of New York Downstate Medical Center College of Medicine.

HUNTINGTON SHELDON, assistant professor, pathology, McGill University Faculty of Medicine (effective 1 July).

THOMAS E. STARZL, instructor, surgery, Northwestern University Medical School (effective 1 July).

AUGUST G. SWANSON, instructor, neurology, University of Washington School of Medicine (Seattle).

WILLIAM G. THURMAN, instructor, pediatrics, Tulane University School of Medicine.

ARTHUR C. WHITE, instructor, internal medicine, University of Louisville School of Medicine.

ALBERT I. WINEGRAD, associate, internal medicine, University of Pennsylvania School of Medicine.

F. EUGENE YATES, associate, physiology, Harvard Medical School.

ROBERT ZEPPA, instructor, surgery, University of North Carolina School of Medicine.

The following scientists have each received a 1958 Viking Fund Medal and a $1000 award from the Wenner-Gren Foundation for Anthropological Research: RAYMOND W. FIRTH, professor of social anthropology at the University of London; HENRI V. VALLOIS, physical anthropologist and director of the Musée de l'Homme, Paris; and JESSE D. JENNINGS, archeologist at the University of Utah.

ROBERT M. PAGE, director of research, U.S. Naval Research Laboratory, Washington, D.C., received the third annual Captain Robert Dexter Conrad Award of the Office of Naval Research. He was honored "for his outstanding contributions to science—especially in the fields of radio communications, radar and electronics—and for his dedicated service to the Navy as a civilian scientist."

ALEXANDER DALGARNO, professor of theoretical physics at Queens University of Belfast, Belfast, Northern Ireland, will be spending the summer as principal physicist with the Geophysics Corporation of America, Boston, Massachusetts.

GEORGE P. SUTTON, Hunsaker professor of aeronautical engineering at the Massachusetts Institute of Technology, has been named chief scientist of the Defense Department's Advanced Research Projects Agency. He will direct the work of 50 scientists and engineers in the Pentagon's space and antimissile research programs.

EMIL WITSCHI, professor of zoology at the State University of Iowa, has been invited by the Minister of National Education of France to serve as visiting professor at the University of Paris. He intends to present lectures on the "Biology of Reproduction" during the spring term, 1 April to 30 June.

DAVID J. PEERY, until recently vice president of Haller, Raymond and Brown, Inc., and JOHN C. STEWART, theoretical physicist at General Electric Company's Knolls Atomic Power Laboratory in New York, have been named research staff members at General Dynamics Corporation's General Atomic Division, San Diego, Calif.

Recent Deaths

WALTER A. ADAMS, Chicago, Ill.; 58; chief of psychiatry at Provident Hospital; conducted a clinic for narcotics addicts at the hospital; had served as a psychiatrist for the Chicago Juvenile Court branch of the Illinois Institute for Juvenile Research; 8 Mar.

MAX GERSON, New York; 77; specialist in the treatment of cancer and tuberculosis; head of a cancer clinic in Nanuet, N.Y.; born in Germany, he came to the U.S. in 1936, after having lectured at European universities; author of *A Cancer Therapy*, which was published in 1958; 9 Mar.

RICHARD B. MILLER, Edmonton, Alberta, Canada; 43; head of the department of zoology at the University of Alberta; vice president of the Wildlife Society of America in 1957; 23 Feb.

S. WEIR NEWMAYER, Philadelphia, Pa.; 79; physician who published 18 books on ophthalmology; had been a medical supervisor for the Board of Education and a medical inspector of the Bureau of Health; 1 Mar.

ROBERT M. OGDEN, Ithaca, N.Y.; 81; dean of the College of Arts and Sciences at Cornell University from 1923 until his retirement in 1945; had taught at the universities of Missouri, Tennessee, and Kansas; past president of the Southern Society of Philosophy and Psychology and of the Association of Colleges and Universities of the State of New York; 2 Mar.

FRANK D. ROSSOMONDO, Haworth, N.J.; 56; medical director of McGraw-Hill Publications in New York since 1912; served on the staffs of Bellevue and French hospitals in New York; 8 Mar.

WILLEM RUDOLFS, New Brunswick, N.J.; 73; specialist on water and sewage problems; retired in 1952 as chairman of the department of sanitation at Rutgers University after having headed the department for 30 years; 20 Feb.

HINSDALE SMITH, Brattleboro, Vt.; 89; early inventor in the automobile industry; together with his brother, operated the Metal Body Company, Springfield, Mass.; developed a six-cylinder automobile; 7 Mar.

FRANK TWYMAN, London, England; 82; pioneer in the development of optical instruments and in spectrochemical analysis; manager of the Otto Hilgers optical equipment firm; developed a method of testing optical components by interferometers; 6 Mar.

Book Reviews

Personal Knowledge. Towards a post-critical philosophy. Michael Polanyi. University of Chicago Press, Chicago, Ill., 1958. xiv + 428 pp. $6.75.

Michael Polanyi's concern in this book is to refute a theory of what science is which is not merely false but which is harmful to the practice of science; he calls it the "objectivist theory," and against it he urges an alternative according to which science is ineradicably "personal." Hence the title of his book, which might, otherwise, be misleading. The book is not so much about our knowledge of persons as about physics, probability theory, crystallography, biology, and so forth, which he argues are *inherently* and not accidentally personal in structure; they are, one and all, personal, yet not "subjective." His problem, therefore, is first to prove that the sciences all conceal at bottom a personal commitment and secondly, to show how that commitment can be personal or responsible, and not whimsical or subjective. I believe he has achieved a large measure of success in the first of these tasks but not in the second.

Increasingly, Polanyi holds, a notion is gaining currency that science is an impersonal activity. To be sure, *men* must raise certain questions, gather relevant data, formulate tentative hypotheses, and, by experimental procedures, confirm their guesses or prove them untenable; but the "objectivist" theory holds that the passions of the scientist, his beliefs, his commitments, his trust in his own unformulated and unformalizable frameworks, and his accreditation of reports, institutions, and his fellow scientists are all of an accidental character. In principle, the entire procedure might be accomplished by a mechanicological apparatus; the person of the scientist is logically irrelevant to problems posed, relevant evidence, symbolic formulations, and final probable truth. All of this is a caricature both of the actual work of science and of its logical structure, according to Polanyi. The person of the scientist functions at the beginning and in the middle, and is present in the final results.

How then does the personal factor manifest itself in the very structure of science? Polanyi discovers it wherever there is an act of appraisal, choice, or accreditation. Each science operates within a conceptual framework which it regards as the "most fruitful" for those facts which it "wishes" to study because they are "important," and thereby it chooses to ignore other facts which are "unimportant," "misleading," and "of no consequence." In short, the framework *selects* out of a chaos of phenomena those circumstances which are susceptible of "fruitful" investigation and formulation. But the framework itself is not selectable by any formalizable process; it represents a passionate commitment by the person of the scientist, a commitment which then proceeds to make itself good, but always to a degree only. The framework itself is never logically decidable by the simple, uninterpreted facts themselves. Further, the conceptual framework itself can never be exhaustively understood by the scientist using it; it has implications beyond what can at any time be foreseen, and the skillful use of it demands a faith in it which can never be adequately grounded by explicit thought. Finally, science in any significant sense is never the work of a single man. The thought of any one scientist would be impossibly trivial unless that man had faith in the skill, reliability, and veracity of a continuing community of investigators.

Scientific knowledge, then, from mathematics through astronomy, physics, chemistry, and biology, is an activity of men who seriously investigate nature from the standpoint of changing conceptual frameworks passionately believed in, within a trusted community of scientists, professionally accredited, using methods which are better described as "skills," "arts," or a kind of connoisseurship than as an impersonal calculus. This in general is Polanyi's argument, and it is demonstrated by a running analysis of a variety of problems within the sciences. Polanyi is a polymath of intimidating scope, and it is far beyond my powers to estimate the reliability as to detail of arguments which touch upon crystallography, relativity physics, genetics, economics, learning theory, probability theory, Gödel's theorem, law, evolution, and, indeed, the entire encyclopedia of modern scientific knowledge. But these have the role of illustrations, and long before the spirit is worn out by the bewildering variety of subjects, Polanyi's thesis has become clear and plausible in outline.

Part 1 considers scientific knowledge as a skill involving connoisseurship, habits, and traditions. "The aim of a skilful performance is achieved by the observance of a set of rules which are not known as such to the person following them" (page 49). An analogy is drawn between scientific knowing and swimming; maxims and rules are useful as guides, but only insofar as they can be integrated into a practical knowledge of the art. Further, in science the inquiry is guided by reference to and belief in a reality which lies far beyond our explicit comprehension. We have clues, but the clues are clues to an ultimate reality not identical with the clues themselves. We use the clues to explore a vision of reality animated by an enthusiastic hope; we hope the patterns of order we have selected will, by leading us on to new discoveries, progressively enable us to explore a physical reality which extends far beyond our theoretical comprehension. Our affirmation of the truth of a theory is an act of *believing* in its significant contact with that reality. Skillful performance rests upon an acceptance of an indefinite number of unformalizable particulars of which we have at best a subsidiary awareness.

Part 2, the largest section, explicitly applies Gestalt theory to scientific knowing. We direct our attention *focally* to a theme, a problem, or a question, but supporting and conditioning that focal or thematic awareness is a background of subsidiary awareness of all that is presupposed in order to make sense out of the focal theme. This vast and unformalizable background Polanyi calls the "tacit component" in knowing, and this is all that must be *believed* if the particular matter under scrutiny is to be doubted or investigated. To say anything whatsoever is to affirm an indefinite number of unsaid things. Language itself supplies such a background of commitment; to speak in a language is to accept the language itself as an adequate framework for true and meaningful speech. Further, we must credit the assertions of others and hope that they share enough of our own framework to make significant agreement or disagreement possible. The whole of scientific discourse occurs within a social medium which must be affirmed in outline: technical journals, a continuing tradition of responsible authorities, institutions, and libraries. Any particular matter within this whole can be doubted and questioned, but we cannot doubt the whole without destroying the conditions for

doubt. Again, Polanyi presents us with the image of scientists necessarily living within a framework of tacit beliefs and commitments, where personal faith is the presupposition of even the most radical revolution. However, as I mentioned above, this faith, while personal, is not "subjective"—that is, not arbitrary or capricious. It is, Polanyi holds, "responsible."

Part 3 attempts a justification of personal commitment, in order to distinguish it from the capricious and the arbitrary. This is, in my opinion, the weakest section of the work. "Within the framework of a commitment, to say that a sentence is true is to authorize its assertion . . . the verification of a statement is transposed into giving reasons for deciding to accept it, though these reasons will never be wholly specifiable" (page 320). Polanyi's problem now is to make sense out of his distinction between the personal and the subjective; for if knowledge contains an irreducible factor of belief—a belief moreover which can never be adequately grounded—how is it to be distinguished from superstition and error? And Polanyi most certainly wants to distinguish science from superstition, wishful thinking, and fantasy. The latter are "subjective"; the former is personal—that is, "responsible." But both rest upon beliefs which can never be formalized or demonstrated adequately. How, then, are the two to be distinguished? And here I must admit to a profound disappointment. "It is enough" Polanyi says, "to establish here once more the principle which distinguishes them: namely, that commitment is personal choice seeking and eventually accepting something believed (both by the person incurring the commitment and the writer describing it) to be impersonally given, while the subjective is altogether in the nature of a condition to which the person in question is subject" (page 302). And a few sentences further on he states, "The scientist pursuing an enquiry *ascribes* [italics mine] impersonal status to his standards and claims, because he regards them as impersonally established by science. But his submission to scientific standards for the appraisal and guidance of his efforts is the *only sense* in which these standards can be said to pre-exist or even to exist at all for him. . . . I can speak of facts, knowledge, proof, reality, etc., within my commitment situation for it is constituted by my search for facts, knowledge, proof, reality, etc., as binding on me. These are proper designations for commitment targets which apply so long as I am committed to them; but they can not be referred to non-committally. . . Commitment is in this sense the only path for approaching the universally valid" (pages 302–303). "*Our claim to speak of reality serves thus as the external anchoring of our commitment in making a factual statement*" (page 311).

And so: if I regard the standards of my activity as universal, "impersonally given," then I am personal and responsible, and my activity is scientific, whereas, if in fact I am merely subject to some condition, then I am in fact "subjective." But, the "facts" in question are themselves facts only for *belief*. Hence, we end up with the spectacle of science calling astrology subjective superstition, since science doesn't "believe" in the "facts" of astrology, and of astrology repeating the compliment with respect to science, since its feeling is reciprocal. Each has its own facts, truths, beliefs; each calls itself personal and responsible and its opponent "subjective" and merely involved in certain mental "conditions"; and there is no way out of the impasse.

Now this last, it should be understood, is the conclusion *I* draw from Polanyi's argument, not his; in short, I do not see that Polanyi has provided us in the end with any means whatsoever for distinguishing truth from error, the personal from the subjective, science from superstition, although he is most anxious to do so. For in Polanyi's universe of discourse there are *no* facts, and there is *no* reality independent of a belief which can never be adequately grounded. But surely this is a serious logical muddle. A madman is not less mad by virtue of the passion of his commitment to his world but more so; and to distinguish him from the sane by saying he suffers from "a condition" becomes meaningless within any system such as Polanyi's where fact is dependent upon sheer belief. The logical muddle consists in mixing together two points of view. If, as Polanyi argues, we must always dwell *within* a framework of belief within which there are such things as "facts" and "truths" but outside of which there are none, then indeed we have no right to adjudge any other belief whatsoever "subjective," except insofar as we simply do not share that belief. Page 304 states this as clearly as one could wish: "The 'actual facts' are accredited facts, as seen within the commitment situation while subjective beliefs are the convictions accrediting these facts as seen non-committally by someone not sharing them." And so after a long argument we come at last to this —that questions of true and false, fact and fiction, science and superstition, are merely questions of two different frameworks, two different beliefs, two different commitments; the ontological war of worlds is now a war of beliefs. And where do we go from there? To put it briefly, I think Polanyi has overstated his case and ends up with such a radical subjectivism that he can no longer make sense of some rather crucial distinctions.

The last section of the book develops a theory of evolution which is something like Bergson's, except that Polanyi's is directed to an end. Life culminates in ourselves, and here Polanyi is thinking of the scientist—men who are responsible to a "firmament of obligations . . . truth . . . greatness, and universality." Life is an "ordering principle" which moves toward "liberating" itself, which it does through commitment and belief, and which progresses toward an "unthinkable consummation." God is the last word in the book. Here Polanyi exhibits an admirably synoptic view and achieves expressions of a high order of disciplined beauty.

This sketchy account, however, utterly fails to do justice to a most impressive book. I believe there is a major flaw in Polanyi's position; but even so, his argument against the "objectivist" school is, for me, decisive. I do believe that Polanyi is too much concerned with tracing every activity of man down to the chimpanzees, bees, and worms, and too little concerned with the ultimate logic of his position. But I should not wish to give the impression that this work is anything but a very major attempt to rethink the conditions of scientific knowledge.

WILLIAM EARLE
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Northwestern Uninversity

The Geology of South Australia. Prepared by members of the South Australian Division of the Geological Society of Australia. M. F. Glaessner and L. W. Parkin, Eds. Melbourne University Press on behalf of the Geological Society of Australia, 1958 (order from Cambridge University Press, New York 22, N.Y.). Illus. + plates. $8.50.

South Australia, far exceeded in area by three other Australian political subdivisions, is larger than Texas by more than 100,000 square miles. Wide plains and low hills characterize much of the land surface, but in the southeastern part of the state, ranges that trend generally northward are locally rugged, with maximum altitudes exceeding 3000 feet. The northwestern section of the state is arid and has extensive areas mantled with dune sand. The eastern part has moderate rainfall, and a large northeastern district is within the Great Artesian Basin.

Bedrock in South Australia includes great thicknesses of ancient sedimentary strata, which are best displayed in low ranges that extend northward from Gulf Saint Vincent. The oldest bedrock unit, mapped as Archean, consists of many deformed and metamorphosed sedimen-

tary beds and intrusive bodies of igneous rock. A minimum thickness exceeding 30,000 feet of the altered strata has been determined. Unconformable on these basement rocks is the Adelaide system of varied sedimentary formations, classified as Proterozoic or late Precambrian, essentially unmetamorphosed and with maximum total thickness of more than 50,000 feet. Extensive glacial deposits are found at two widely separated horizons in this thick section. Marine formations of Cambrian age, many thousands of feet thick, were laid down conformably above the Adelaide system. Deformation that began later in the Cambrian period culminated in the early Paleozoic orogeny. The resulting chain of mountains extended from Kangaroo Island, southwest of Adelaide, at least 1000 miles to the north and northwest. The present low chains in the state are remnants of this ancient mountain belt, after repeated uplifts, erosion, and local burial by younger sedimentary deposits.

Except for limited outcrops of beds dated doubtfully as Ordovician, the only Paleozoic rocks known to have been formed in South Australia after the mountain making are Permian glacial deposits, which locally rest on glaciated bedrock floors. Mesozoic deposits, partly marine and partly continental, have limited distribution and thickness and are only moderately deformed. Workable coal beds occur locally in Triassic sections. During Cenozoic time some downwarped areas received marine sediments; a widespread cover of continental deposits was formed, and important local uplifts have resulted from warping and faulting.

Details of the geology and of the inferred history are presented in ten chapters, each dealing with a specific province of the state. A brief summarizing chapter integrates the salient points. Geology is represented without topography, on black-and-white sheets—some page-size; others folded tip-ins; the four largest, separate sheets in a pocket. The scales of these maps range from 8 to 16 miles to the inch. The one complete map of the state, in color, is a one-page frontispiece, with scale one inch to 120 miles. Stratigraphic and structural relationships are clearly represented by diagrams, sketches, and a number of excellent halftone plates.

Thus, the treatise is brief and in large part of reconnaissance character. Nevertheless it is a welcome reference volume, presenting the salient geologic features of the entire state and bringing together for the first time much critical information won through field studies during the past 30 years.

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Descriptive Meteorology. Hurd C. Willett and Frederick Sanders. Academic Press, New York, ed. 2, 1959. xix + 355 pp. Illus. $7.50.

This book is very useful. It is a welcome revision of the first edition, which was written, like so many meteorological texts in the United States, as an aid for the training program of World War II. Thousands of weather forecasters were needed by the Armed Forces. At that time the emphasis was on mapping, analysis, and forecasting of weather features. The senior author (who has acquired an able collaborator in this second edition) tried then to meet both the practical demands and the requirements for thorough understanding.

The present volume backs off a little from the practical aspects. It makes up fully for this change by an expanded and much more penetrating probing into the behavior of the atmosphere. After a relatively brief introduction to the thermal and radiative properties of the air, most of the space is devoted to atmospheric motions. The general circulation of the atmosphere and the smaller circulation systems embedded in it and the relative interdependence of these systems, together with their causes, are extremely well discussed. In particular, the chapter on secondary circulations of the thermal type, which includes the monsoons and tropical storms, is excellent. The confusing assortment of currents and eddies, which so bewilders the beginner in atmospheric science, is presented as a logical system. The shortcomings are those inherent in our lack of knowledge of many of the phenomena.

A final chapter is devoted to weather forecasting and weather modification. It contains no magic recipes for either. Rather, the authors give a critique of present capabilities and a seasoned outlook regarding what may reasonably be expected in the next decade or two. In neither field is there anything to please the pseudo scientists who have stirred up extravagant hopes for perfect forecasts and widespread weather control. The research path is a long and hard one, and the incipient meteorologist might as well know it.

This book is designed to give information at the professional level in the field of meteorology. It will serve best in conjunction with a course on the subject, for it raises questions that a beginner will have difficulty in answering for himself. But it can admirably support the necessary companion studies on meteorological observation, dynamic meteorology, and the synoptic laboratory.

On one point I find myself out of step with the authors. In the whole text only five persons are named (presumably, because basic material came from their papers). This leaves the student entirely without historical perspective of the field and its development. I am sure there is little doubt about the stature of Rossby, V. Bjerknes and J. Bjerknes, Palmén, and a good many others. Why not give them credit for their contributions? This would not necessarily require extensive literature citations, which the authors expressly wanted to avoid.

On the whole, it is gratifying to see this addition to the solid texts in a field which needs to attract much talent in the future to help in the solution of its many problems.

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Advances in Chemical Physics. vol. 1. I. Prigogine, Ed. Interscience, New York, 1958. xi + 414 pp. Illus. $11.50.

This is the first of a series of volumes which, it is anticipated, will be published annually. The field of chemical physics is assumed to include such problems as those of chemical kinetics, molecular physics, molecular spectroscopy, transport processes, thermodynamics, the study of the states of matter, and the variety of experimental methods used. The purpose of the series is to make available a group of comprehensive articles each of which is the report of an expert in a particular field, who explains his view on a subject freely and without limitation of space. For the most part the articles are of a review nature and are well done, at an authoritative, advanced level; they are not exactly light reading for one not a specialist in the field under treatment.

The emphasis in this volume is on nonequilibrium effects in transport processes and chemical kinetics, but several articles on other subjects are included. The titles and authors represent adequately what one may expect to find in the volume: "Statistical mechanical theory of transport processes. X. The heat of transport in binary liquid solutions" (13 pages), Richard J. Bearman, John G. Kirkwood, and Marshall Fixman; "Theoretical and experimental aspects of isotope effects in chemical kinetics" (62 pages), Jacob Bigeleisen and Max Wolfsberg; "Some physical aspects of gaseous chemical kinetics" (16 pages), G. Careri; "Dielectric properties of dilute polymer solutions" (42 pages), L. de Brouchere and M. Mandel; "Transport processes in liquids" (30 pages), Frank C. Collins and Helen Raffel; "The relation between structure and chemical reactivity of aromatic hydrocarbons with particular reference to carcinogenic properties" (37 pages), R. Daudel; "Molecular theory of surface tension" (35 pages), A. Harasima; "Re-

cent developments in molecular orbital theory" (27 pages), H. C. Longuet-Higgins; "Intermolecular forces and equation of state of gases" (31 pages), Taro Kihara; "On statistical mechanics and electromagnetic properties of matter" (52 pages), P. Mazur; and "The application of the theory of stochastic processes to chemical kinetics" (38 pages), Elliott W. Montroll and Kurt E. Shuler.

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Flavor Research and Food Acceptance. A survey of the scope of flavor and associated research, compiled from papers presented in a series of symposia sponsored by Arthur D. Little, Inc. Reinhold, New York; Chapman and Hall, London, 1958. vi + 391 pp. Illus. $10.

This book, based on a series of four symposia organized by Arthur D. Little, Inc., in 1956–1957, integrates the related aspects of food flavor revealed by sensory testing, consumer testing, psychology, physiology, and chemistry. The topics are presented by leading authorities among research consultants, universities, government research laboratories, and the food industry. The physiological basis of flavor is described as the adsorption of certain characteristic chemical components on the surface of the taste receptor cells on the tongue, which results in electrical depolarization of these "chemoreceptor" surfaces. This in turn induces electrical impulses in the nerve fiber; the frequency of these impulses is directly related to the strength of the chemical taste stimulus. Electrophysiological tests on single nerve fibers of the rat show that most of these fibers respond in varying degrees to more than one of the salt, sour, bitter, and sweet categories. These sensations, therefore, do not correspond to individual basic receptor types.

Organoleptic testing by laboratory panels is described in terms of techniques for detecting difference from a standard. The statistical significance of the findings is shown to be dependent on panel size, degree of difference sought, and design of the test. Descriptive testing of complex flavors can be accomplished by the flavor-profile method originated by Arthur D. Little, Inc. This is a method of subjective analysis by trained panels, which considers total flavor amplitude plus independently recognizable aroma and flavor components, according to type, intensity, and order of perception. Methods of scoring and ranking flavors are discussed, both generally and specifically, in relation to dairy products. Suggestions are offered with respect to selection of experimental media to use in evaluating separate flavor components, methods for separating odor samples and presenting them to test subjects, and adequate design and control of the test environment (the physical setting, handling of samples, and selection, training, and motivation of judges).

A chapter devoted to the importance of new-product development from management's point of view emphasizes the need for business-economic appraisals of market and profit opportunity to guide research. Consumer testing serves to reduce the risks attendant on product development.

Some classifications of tests are presented, including the following: (i) blind paired comparisons; (ii) paired comparisons of identified products, in which identification allows for the effects of the package or the product image in the consumer's mind; (iii) monadic testing, in which standard, experimental, and competitive products are randomly sampled in identical packages (one to each tester), and in which a later survey is used to determine the acceptance of experimental samples relative to the total market; (iv) scaling tests, useful when there are several contending experimental products; (v) continued-use tests to establish the duration of an initial acceptance or rejection; and (vi) multiple-paired comparisons, in which a number of variables may be appraised in a statistical design; this test provides more information than is available from stepwise paired comparisons without requiring an increase in the number of testers.

A chapter devoted to the Nielsen method of market analysis shows how sales trends can be used to measure the effects of new-product promotion and to study the vulnerability of established products.

A section of seven chapters gives in detail the experiences of six food manufacturers and one oil refiner in their applications of organoleptic product-acceptance testing.

The final section covers analytical investigations of complex natural flavors by physicochemical separation of their important components. Some of the tools employed for these purposes are described—for example, distillation, selective solvent extraction, liquid and vapor phase chromatography, countercurrent distribution between immiscible solvents, mass spectrometry, and infrared spectroscopy. A recent approach to flavor development in processed foods is described, which employs postprocessing treatment with specific enzymes designed to react with surviving flavor precursors. The chromatographic separation of strawberry oil derivatives in the Swiss laboratories of Firmenich is described, with experimental details. A parallel study made in the U.S. Department of Agriculture laboratories, which employed vapor phase chromatography, is also presented.

Investigations of flavor in dairy products emphasized the usefulness of the 2,4-dinitrophenylhydrazine derivatives in identifying flavor components. The odor of Cheddar cheese has been related to beta-methylmercaptopropionaldehyde. Following a chapter on the analytical separations of limonene sulfides, analytical details and extensive data on the composition of citrus oils are reported, from the U.S. Department of Agriculture laboratories in California.

A summation chapter by A. J. Haagen-Smit draws a rather tenuous thread of continuity through the otherwise loosely related separate chapters. Several chapters carry extensive bibliographies, and an alphabetical subject index is provided.

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International Directory of Psychologists Exclusive of the U.S.A. Prepared for the National Academy of Sciences-National Research Council by the Committee on an International Directory of Psychologists, Division of Anthropology and Psychology. Publication 520. Eugene H. Jacobson, Ed. H. C. J. Duijker, European Co-Editor. National Academy of Sciences-National Research Council, Washington, D.C., 1958. xii + 527 pp. $5.

This book contains information about psychologists in all countries outside the United States. Plans for this directory were prepared by a committee of the National Academy of Sciences–National Research Council; Edwin G. Boring served as chairman of the committee. Since the American Psychological Association publishes a directory of psychologists in the United States, it was decided that the *International Directory* should not duplicate that effort.

The arrangement of the directory is alphabetical by country and by name under each country. The following information is supplied for each entry: Name and title; preferred mailing address; date of birth; place of birth; highest earned academic degree; university granting degree and year in which degree was granted; membership in professional societies; editorial responsibilities; current occupation; primary fields of interest in psychology; and sex.

An index of names adds to the usefulness of this compilation.

Reports

Significance of Diaspore at Magnet Cove, Arkansas

Abstract. The Magnet Cove magmas developed essentially monometallic phases during the later stages of crystallization. The finding of diaspore indicates that an aluminum-rich phase was present. Barium- and titanium-rich phases have already been reported.

The Magnet Cove alkalic intrusive masses near Hot Springs, Arkansas, have been collecting grounds for unusual rocks and minerals for over 150 years. The only published comprehensive study of these igneous rocks is the report of Williams (*1*). Several reports have been written about certain features of the cove complex (*2*), but no outstanding additions to Williams' work were made until data became available from a detailed study initiated by the U.S. Geological Survey in 1952. A rock-distribution map (*3*) has been published, but a wealth of geochemical (*4*) and petrographic data must be assimilated before a complete report is released.

The U.S. Geological Survey, through cooperative agreement with the Arkansas Geological and Conservation Commission, allowed the use of geochemical data which pertained to a study of the origin of the barite ($BaSO_4$) in the Ouachita Mountain area (*5*). One of the contributive discoveries was that the feldspars of some rock types within the cove complex were saturated ionically with barium. The fact that these rocks are also supersaturated with titanium is well documented (*2*).

Diaspore was found on a joint face of a quartzite bed in the lower part of the Stanley formation about 80 feet above the channel of Stone Quarry Creek in the southeast quarter of section 29, T. 3 S., R. 17 W. The nearest exposure of igneous rock is upslope 180 feet to the north. The diaspore occurs as small scattered grains on subhedral quartz. Patches of yellow- to light-brown hydrous iron oxides are associated with the diaspore.

Against the quartz background the highly lustrous diaspore grains appear to be black and closely resemble the brookite (TiO_2) on the northeast rim of the cove. However, under the hand lens and microscope the diaspore grains are blue and translucent. Except for the rather deep blue color, the physical properties are in excellent agreement with published descriptions. The optical properties vary somewhat from published data, but x-ray diffraction patterns made by R. F. Kruh at the University of Arkansas confirmed the diaspore identification. The deep blue color and slightly anomalous optics are caused, at least in part, by spectrographically detectable quantities of titanium in the diaspore.

The available evidence indicates that the fluids from which the diaspore was deposited escaped from the intrusive body along joints in the country rock. The titanium in the diaspore was expected because all the late-stage rock and mineral aggregates, including the barite, of the cove complex contain appreciable amounts of titanium. The subhedral quartz associated with the diaspore shows preferred growth direction along the joint face. This indicates that the egressing fluids flowed long enough and were of sufficiently high temperature to cause selective recrystallization and growth of the formless quartz grains of the quartzite. The diaspore is concentrated on the sides away from the intrusives of the larger quartz grain aggregates. The iron oxides were the last to form and are attached to both the quartz and diaspore. The egress of the aluminum-bearing fluids, like that of the barium-bearing and titanium-bearing fluids from which the barite and brookite were deposited, was through fractures and joints in the country rock. These deposits were formed from concentrations developed in the later stages of crystallization of the Magnet Cove magmas (*2, 5*).

The igneous rocks of Magnet Cove are chiefly medium- and coarse-grained nepheline syenites and fine-grained or aphanitic syenite equivalents. The syenitic rocks are cut by mafic (Mg-Fe rich) dikes. The granites are oversaturated with silica and therefore contain quartz, the syenites are saturated, and the silica is bound in the feldspars; the nepheline syenites are silica-deficient. In silica-deficient systems aluminum excesses are ordinary and aluminum oxides, mostly corundum (ruby, sapphire), are characteristic in the mineral assemblages.

The discovery of diaspore shows that the crystallizing Magnet Cove magmas in some phases did have an excess of aluminum. The aluminum-bearing fluids escaped through the fractured wall rock. There may have been much more diaspore formed than was found, but the possible host rocks have been removed by the erosion activity of Stone Quarry Creek. The minor amount of diaspore on the joint face is the only known trace of the aluminum-bearing fluids.

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6 October 1958

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Tryptophan Loading and Excretion of 5-Hydroxyindoleacetic Acid in Normal and Schizophrenic Subjects

Abstract. In contrast to the findings of Zeller *et al.* (*1*), schizophrenic patients did not differ from normal control subjects in the rate of 5-hydroxyindoleacetic acid (5-HIAA) excretion either before or after oral administration of L-tryptophan. The excretion of 5-HIAA may be directly related to dietary tryptophan since feeding-problem schizophrenic patients excreted less 5-HIAA than either of the well-fed groups. This was not related to pyridoxin deficiency.

The suggestion by Woolley and Shaw (*2*) that an abnormal metabolism of serotonin may be of etiological importance in mental disease has inspired many attempts to demonstrate abnormalities in the metabolism of this com-

Table 1. Effect of 5 g of L-tryptophan on the rate of urinary excretion of 5-HIAA (micrograms per hour).

Subject	No.	Rate		Increase
		Before tryptophan	After tryptophan	
National Institutes of Health				
Normal	6	229 ± 68	448 ± 53	219 ± 110
Schizophrenic	16	190 ± 91	373 ± 164	183 ± 93
Spring Grove State Hospital				
Schizophrenic*	8			
Before pyridoxine		128 ± 85	300 ± 159	172 ± 104
After pyridoxine		143 ± 106	299 ± 161	156 ± 132

* Feeding problem patients.

pound in schizophrenia. L-Tryptophan is the normal dietary precursor of serotonin, and 5-hydroxyindoleacetic acid is the major urinary metabolite of this amine. Zeller *et al.* (*1*) have reported that schizophrenic patients differ from normal control subjects in failing to excrete an increased amount of 5-HIAA after oral administration of large doses of L-tryptophan. Layton (*3*) found that 20 percent of a hospitalized group of schizophrenics excreted less 5-HIAA than any of the normal subjects he encountered. He suggested that 5-HIAA excretion might be used as a biochemical basis for separating a subgroup of schizophrenics.

We have attempted to repeat these findings of Zeller (*1*) and Layton (*3*) in 16 healthy male schizophrenic patients who had been living in the wards of the National Institutes of Health for at least 2 months under the same conditions and on approximately the same diet as six nonschizophrenic volunteers who served as controls. Five grams of L-tryptophan suspended in 200 ml of orange juice were administered orally. The amounts of 5-HIAA excreted in the urine (*4*) during the following three 2-hour intervals (total of 6 hours) were compared with the amounts excreted over the same time intervals during the previous day, when only orange juice had been fed. No significant differences in the rate of 5-HIAA excretion were noted between the schizophrenic and control groups before or after administration of tryptophan. Both groups showed similar increases in the rate of 5-HIAA excretion after administration of tryptophan (Table 1).

Weissbach *et al.* (*5*) demonstrated that serotonin levels in tissue are decreased in pyridoxine-deficient chicks. 5-Hydroxytryptophan decarboxylase activity is reduced in the vitamin B_6 deficient rat (*6*). An attempt was therefore made to relate pyridoxine deficiency to 5-HIAA excretion. Eight male schizophrenic patients who had been long-term feeding problems were studied at the Spring Grove State Hospital (*7*). The rate of 5-HIAA excretion was determined before and after tryptophan loading in the same manner as described for the first study. Following this the patients received 50 mg of pyridoxine hydrochloride orally, three times daily for 5 days. The rate of 5-HIAA excretion before and after tryptophan loading was again determined (Table 1). The rate of excretion of 5-HIAA before tryptophan loading in the feeding-problem group seemed lower than that in the well-fed group of patients and was possibly related to protein and tryptophan ingestion ($p = .10$). Dietary deficiency of protein or tryptophan may therefore explain the findings of Layton (*3*). The increase in excretion of xanthurenic acid following the tryptophan load was used in the estimate of the degree of pyridoxine deficiency (*8*). This was not related ($r = .144$) to the rate of 5-HIAA excretion, and pyridoxine administration did not affect this rate. After administration of tryptophan, the rate of excretion of 5-HIAA by the feeding-problem group of schizophrenic patients increased, just as it did in the well-fed schizophrenic and control groups.

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26 January 1959

Seasonal Growth Periodicity of Tissue Explants from Woody Perennial Plants in vitro

Abstract. Secondary phloem explants removed to standard aseptic culture in the spring proliferate most extensively. Explants taken successively through the growing season proliferate less. The decreasing growth trend reverses some months before bud break, and the increasing growth in winter is not dependent on the breaking of dormancy in the terminal buds.

The growth of perennial plants is markedly periodic. Growth activity in the meristems of the shoot, which commences in the spring with the onset of warmer weather, ceases in the summer while external conditions are still favorable for growth. Developmental periodicity is accompanied by changes in auxin or growth-inhibitor content and can be regulated to some extent by variations of day length. Explanations of periodic growth activity have noted such changes (*1*). However, the physiological basis of growth periodicity remains obscure.

Sterile culture techniques which have been applied so successfully to problems of tissue and organ growth have scarcely been used in the study of growth periodicity (*2*), and the study described in this report was an attempt to apply such methods to this problem (*3*). The approach adopted was that differences in growth potential of tissues excised from donor plants at different times of the year should be reflected either as quantitative or qualitative differences of growth in sterile culture.

Data on the growth of tissue explants in culture are being accumulated for 11 species. These are: *Ginkgo biloba,* four diffuse-porous dicotyledons (*Salix babylonica, Populus nigra* var. *italica, Syringa vulgaris,* and *Acer rubrum*), and six ring-porous dicotyledons (*Ailanthus glandulosa, Fraxinus americana, Catalpa bignonioides, Robinia pseudoacacia, Quercus alba,* and *Q. borealis* var. *maxima*). Secondary phloem was selected as the test tissue because of its functional and morphological uniformity and its known ability to proliferate in sterile culture.

The experimental procedure was as follows. At intervals of about 6 weeks a branch 2 to 3 cm in diameter was collected from each species. Short pieces of the branches were surface sterilized, an aseptic surface of secondary phloem was exposed, and rectangular explants were removed. The average-sized explant was 4 by 12 mm, and the fresh weight was between 30 and 100 mg for most species. Twelve explants from each species were inoculated apical end down, to take ad-

vantage of the polar movement of auxin, into each of three media. The simplest medium contained inorganic salts (*4*), trace elements (*4*), and 4 percent sucrose and was solidified with 0.8 percent agar. The second medium contained in addition to these constituents a mixture of vitamins (*5*) and naphthalene acetic acid (NAA) (0.5 mg/lit.). A third medium contained all of these constituents with the NAA concentration reduced to 0.05 mg/lit. and 15 percent autoclaved green coconut milk. The explants were grown in culture for 5 weeks in 12-hour days at 25°C. Approximately 3 percent of the cultures were discarded as contaminated by microorganisms.

Explants of all species proliferated in culture. However, the ability of the explant cells to divide at different times of the year, the amount and morphology of the callus formed, and the relative growth made on the different media varied considerably from species to species.

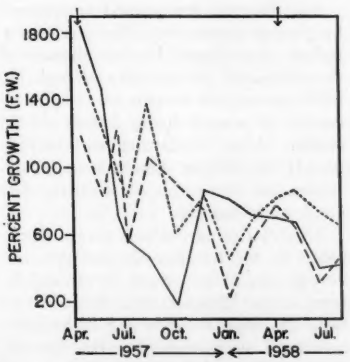

Fig. 1. Final fresh weight of lilac tissue explants cultured at different times of the year calculated as percentage of growth. The dotted line represents the average weight of explants cultured on the simplest medium, the dashed line the weight on the vitamin medium, the solid line the weight on the coconut milk medium. The arrows at the top indicate the approximate date of bud break in the donor plant.

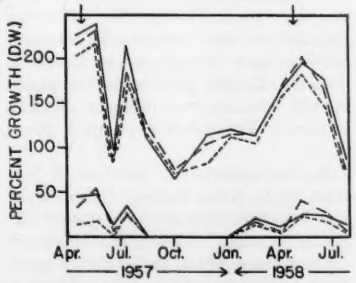

Fig. 2. Final dry weight of maple tissue explants cultured at different times of the year calculated as percentage of growth. The three upper curves represent the average weight of the entire explants, the three lower curves the average weight of proliferated callus. The identification of the lines and arrows is the same as that in Fig. 1.

Explants of lilac proliferated throughout the year and most extensively of the species studied (Fig. 1). Maximum growth on all media, as indicated by increase of fresh weight, dry weight, and size, was obtained with explants removed from the donor plant near the time of bud break in the spring; tissues removed progressively later in the summer proliferated less, but there are unexplained fluctuations in the data for 1957. The coconut milk medium which had supported the highest level of growth in the spring was highly inhibitory to the growth of late-summer explants. On all media the decreasing growth trend was reversed several months before bud break so that there was a gradual increase toward the spring peak. The final fresh weight of the tissues for the spring of 1958 was approximately half that for the spring of 1957, but the dry weights were almost identical. At present there is no adequate explanation for the variation in growth for these 2 years. It may be suggested, however, that weather differences between the years 1957 and 1958 underlie the growth variations, and it is hoped that data to be collected during 1959 will aid in the interpretation of these apparently conflicting results. Other differences in the callus formed at different times of the year included the ratio fresh weight:dry weight and xylem formation, which decreased through the growing season.

Seven other species proliferated through all or most of the year and showed growth periodicity like that of lilac. Explants of the species *Acer* and *Quercus* proliferated during shorter periods. Only those explants of maple removed between February and August proliferated in culture, most callus being formed near bud break time, and for several months before proliferation occurred successive explants showed increases in weight (Fig. 2). To determine whether this winter growth trend was related to the breaking of physiological dormancy in the terminal buds, shoots were brought indoors each time cultures were established. No vegetative buds opened in any of these tests.

These results indicate a periodicity in the growth potential of tissues from perennial species cultured in vitro. In all species most growth occurs near the time the vegetative buds open and diminishes through the summer. Developmental differences in explants removed during the growing season may account for some part of the observed growth trend. However, from the time the vascular tissues mature in late summer successive explants are anatomically identical. Growth differences in culture would then indicate physiological differences in the tissues. Of particular interest is the winter period of increasing growth which occurs at a time when the terminal buds are still in a state of physiological dormancy. Secondary phloem tissue does not exhibit a period of dormancy like that of the buds, but it does exhibit growth periodicity. Tissue-culture methods appear to be well suited to the study of this problem.

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13 October 1958

Parthenogenesis in Culex fatigans

Abstract. Parthenogenesis occurs in the mosquito *Culex fatigans*. Three larvae were hatched from 85,851 eggs in tests of eggs from 1001 females. There were 618 egg rafts; the three larvae were from different rafts.

Parthenogenesis in mosquitoes has been recently reported in two species, *Culex molestus* (*1*) and *Aëdes aegypti* (*2*). Some puzzling results of species crosses in the genus *Aëdes* may possibly be explained by parthenogenesis (see *3*), and it is possible that this phenomenon may be more widespread than is presently suspected.

This paper reports parthenogenesis in a strain of *Culex fatigans*, derived from the Galveston strain in February 1948 and maintained by inbreeding since that date.

During 1957 and 1958 females of this species were tested for parthenogenesis. Single pupae were sexed and then isolated in shell vials. After hatching, the females were checked visually, then etherized and examined under a dissecting microscope. Thus triply checked for sex, the females were placed in a cage (40 cm on a side) and allowed to feed on pigeons. After a blood meal some *Culex* females will lay unfertilized eggs,

although not all females will do so. Eggs were collected daily, observed carefully for 4 days, then discarded. Fertilized eggs normally hatch, under laboratory conditions, 24 to 48 hours after deposition.

During these experiments 1001 females laid 618 egg rafts containing 85,851 eggs. Three first-stage larvae hatched. The three hatched larvae were in three different rafts; thus, in each case only one of approximately 140 eggs hatched. It cannot be argued, therefore, that a male had somehow escaped detection, for if fertilization had in fact occurred, all or nearly all of the eggs in the raft should have been fertile.

All three larvae were weak. One survived the first molt but died soon thereafter; the other two died a few hours after hatching.

Species crosses in *Culex* (*4*) usually produce some eggs which are fertile but which fail to hatch. Such eggs, if sufficiently developed, can be identified under the dissecting microscope. A sampling of 150 egg rafts (containing an average of 125 eggs per raft) from the parthenogenesis experiments failed to reveal any such fertile but unhatched eggs.

Parthenogenetic development, therefore, apparently does occur in *Culex fatigans,* but the frequency of such occurrences is low (*5*).

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16 October 1958

Selection of Auxotrophic Bacterial Mutants by Tritium-Labeled Thymidine

Abstract. A method is proposed for the efficient isolation of auxotrophic mutants of cells of diverse origin by the use of radioactive materials. An example is described in which mutants of *Escherichia coli* B were selected by growing irradiated cells in the presence of tritium-labeled thymidine.

Bacterial mutants with specific nutritional requirements have been used extensively in biochemical and genetic studies. These auxotrophic mutants are ordinarily selected with efficiency by incubation of a mixed culture in minimal medium with penicillin. The growing wild-type are killed, and the dormant mutant cells are spared (*1*).

Many cell species which can be grown in culture are not sensitive to penicillin. No convenient method exists, with few exceptions, for selecting auxotrophic mutants of these cell species (*2*). It seemed possible that an alternative approach might be provided by radioactive materials, such as tritium-labeled thymidine (thymidine-H^3) of high specific activity. Growing cells of both plants and animals incorporate thymidine into deoxyribonucleic acid (DNA) (*3*), and localization of thymidine in the nucleus has been demonstrated by autoradiographs of thymidine-H^3 (*4*). The addition of thymidine-H^3 to HeLa cells growing in tissue culture has recently been shown to decrease viability by as much as 50 percent (*5*).

This report (*6*) describes an initial test of the proposed method in a system which has been studied extensively. First a reconstruction experiment was done with wild-type *Escherichia coli* B and a histidine auxotroph. These were grown separately on *enriched* medium [medium A (*7*) supplemented with 0.2 percent Difco yeast extract and 0.2 percent Sheffield tryptic casein hydrolyzate]. After washing, a suspension of each was placed in 1 ml of *minimal* medium A to which 0.1 ml of thymidine-H^3 was added (*8*). After dilution, the activity of tritium was 40 μc/ml, and the concentration of carrier thymidine about 4 μg/ml (*9*). The cells were incubated at 35°C for 3.5 hours, by which time the count of viable wild-type cells per milliliter had increased from 10^6 to 10^7. Half of each sample was removed, and the remainder was reincubated. After an additional 2.5 hours, wild-type had increased to $5 \cdot 10^7$. The number of histidine auxotrophs was not significantly changed by incubation. A control without thymidine-H^3 was included. After incubation, all samples were stored at 5°C.

Table 1. Decrease in viability after growth in the presence of tritium-labeled thymidine.

Tube No.	Thymidine-H^3 (μc/ml)	Duration of incubation (min)		Viable bacteria after cold storage (No./ml)		
		Before addn. of thymidine-H^3	After addn. of thymidine-H^3	0 days	7 days	13 days*
1	45	0	130	$6.6 \cdot 10^7$	2,600	190
2	45	45	85	$7.5 \cdot 10^7$	1,800	340
3	45	90	40	$6.0 \cdot 10^7$	3,000	210
4	15	0	130	$16.0 \cdot 10^7$	14,000	5200
5	15	45	85	$9.6 \cdot 10^7$	6,600	2100
6	15	90	40	$9.0 \cdot 10^7$	17,000	2400
7	0	130		$11.0 \cdot 10^7$	$3.0 \cdot 10^6$	
8	0	130		$15.0 \cdot 10^7$	$1.4 \cdot 10^6$	

* In all samples at 13 days, the fraction of mutant colonies exceeded 50 percent.

Viability was determined at intervals by plating appropriate dilutions on enriched agar plates. In the absence of thymidine-H^3, the viability of both the wild-type and the mutant fell to approximately 10 percent during 6 days of cold storage. After incubation with thymidine-H^3 the mutant showed a similar decrease, but the count of wild-type fell much more sharply.

The fraction of mutants surviving, divided by the fraction of wild-type surviving, can be expressed as an enrichment ratio. Without thymidine-H^3 this ratio was approximately 1. For the tubes incubated with thymidine-H^3 for 3.5 hours, the enrichment ratio at the end of 6 days of storage was about 4000. In the samples incubated with thymidine-H^3 for 6 hours, the ratio was only 70.

In a mutant isolation experiment, wild-type *E. coli* B were treated with ultraviolet radiation to approximately 1 percent survival. One-half of one milliliter was added to 5 ml of enriched medium and incubated for 24 hours. The cells were washed, diluted by 10^3, and 2.5 ml of the suspension placed in each of eight tubes. The amount of thymidine-H^3 and the time of addition were systematically varied, as is shown in Table 1. During the incubation period of 130 minutes, two to three divisions occurred. The tubes were then stored at 5°.

In this experiment, survival of bacteria in the tubes lacking thymidine-H^3 was 1 to 3 percent after 7 days at 5°C. In the presence of thymidine-H^3, survival was about 1/100 to 1/1000 as great. Each tube was carefully kept cold when samples were removed. After 7 days a search by the replica plating technique (*10*) showed that mutants were present at a frequency of 5 to 10 percent. At 13 days, the yield of mutants was above 50 percent, and in a few cases as high as 90 percent. Although killing of bacteria was greater with 45 μc (tubes 1 to 3) than with 15 μc (tubes 4 to 6), the fractions

of mutant colonies in these two groups were similar. No mutants were recovered from colonies not exposed to thymidine-H^3 (tubes 7 and 8). The number of mutants isolated can be accounted for by supposing that thymidine-H^3 acts as a selective lethal agent for cells that have grown in its presence.

On theoretical grounds, it does not seem likely that much of the selective killing of wild-type could be caused by radiation from thymidine-H^3 in the surrounding solution. The emitted beta particle has an average energy of 5.7 kev and a range in water of about 1 μ. In these experiments the ratio of fluid volume to bacterial volume was about 10^4, and almost all the radiation originating in the surrounding fluid would fail to reach the bacterial cells. This argument is supported by the results of the reconstruction experiment, in which the presence of thymidine-H^3 did not accelerate killing of the histidine auxotroph.

In addition, aliquots from tubes 1 to 8 of the mutant isolation experiment were diluted sixfold after the period of incubation and stored at 5°C. Almost as many mutants were isolated from these samples as from the undiluted tubes. This suggests that thymidine-H^3 is incorporated into the cells in a form unable to diffuse out during cold storage.

In a third experiment, the bacterial suspension was diluted considerably, so that the count at the end of incubation was only 10^6 per milliliter. Killing was rapid, presumably because the amount of thymidine-H^3 per cell was high, and after 5 days of cold storage the yield of colonies which were mutants ranged from 10 to 50 percent.

Among the auxotrophic mutants isolated by this procedure the following requirements have been identified: arginine, cystine, glycine, histidine, isoleucine, leucine, methionine, proline, serine, threonine, tryptophane, tyrosine, valine, isoleucine plus valine, and multiple aromatic compounds. These experiments show that thymidine-H^3 is an efficient selective agent for the isolation of auxotrophic bacterial mutants. The method may be applicable to other species of cells.

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15 October 1958

Mutagenic Effect of Azaserine in Relation to Azaserine Resistance in Escherichia coli

Abstract. For demonstration of the mutagenic effect of azaserine (mutation from streptomycin dependence to nondependence), higher concentrations of this antibiotic are required with azaserine-resistant *Escherichia coli* than with the sensitive, parental strain. At barely toxic concentrations of azaserine, however, the mutagenic response of the resistant strain is many times higher than that of the sensitive strain.

The suitability of azaserine as a chemical mutagen in elucidating the mutagenic process in *E. coli* has been evaluated and described in an earlier publication (*1*). Like most other mutagens, azaserine induces mutations with increasing frequency at concentration levels that are increasingly bactericidal. Nevertheless, it is one of the few known chemical mutagens which is appreciably mutagenic at levels relatively nonbactericidal. This poses the important question as to whether the process of azaserine-induced mutagenesis is related to the bactericidal property or whether the two phenomena are independent of each other. With this question in mind, a comparative study of the mutagenic response in mutants of a streptomycin-dependent strain of *E. coli*, showing varying degrees of azaserine resistance, was initiated (*2*).

From the parent Sd-4 strain (A) (*3*), mutants (B, C) resistant to varying levels of azaserine (*4*) were derived by methods based on the gradient plate principle (*5*). These were maintained on nutrient agar containing 100 μg of streptomycin per milliliter and concentrations of azaserine increasing from 0 to 1000 μg/ml. Washed cells from agar slants were used as inocula for the experiments. Details of the methods were the same as those described in an earlier paper (*1*). The effect of exposure to varying concentrations of azaserine for a period of 2 hours at 32°C on the survival of azaserine-sensitive (A) and azaserine-resistant (B, C) strains and on the mutation rate to streptomycin independence was studied.

The results, selected as representative of several independent experiments, are presented in Fig. 1. They suggest that azaserine is able to induce mutations in azaserine-resistant strains of *E. coli* only at concentration levels much above that required for mutagenesis in the parent, sensitive strain. It is apparent that, in strains resistant to azaserine, an increase in the mutation rate comparable to that produced in the more sensitive parental culture is obtained only at higher concentrations of the mutagen. Comparable results were obtained with several additional, independently isolated azaserine-resistant mutants. A closer analysis of the data, however, reveals that the resistant strains treated at barely bactericidal concentrations of azaserine show a higher mutagenic response than the sensitive parent under comparable conditions.

The data presented suggest that although the mutagenic and bactericidal effects of azaserine are correlated, the quantitative responses are not identical. If the bactericidal effects of azaserine on sensitive and resistant cells are regarded

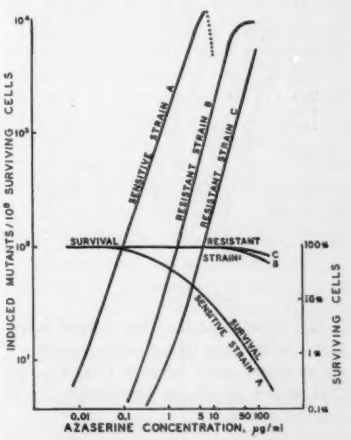

Fig. 1. Effect of azaserine concentration on the number of induced mutants (mutation from streptomycin dependence to independence) and on the percentage of survivors, assessed with azaserine-sensitive strain Sd-4 of *E. coli* and two azaserine-resistant mutants derived from that strain. Two hours' exposure in distilled water at 32°C.

as separate lethal mutations, the differential effect of this mutagen on survival and on suppressor mutations to streptomycin independence could be considered analogous to the differential mutagenic effect of a mutagen on different genes, as observed by Demerec (*6*).

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9 October 1958

Measurement of Regional Blood Flow by Indicator Dilution

Abstract. Appropriate selection of injection and collection sites permits quantification of certain regional blood flows by the single-injection, indicator-dilution method. Quantifying formulas are derived, and application of the method to several regional beds is described.

The indicator-dilution method (*1*) is used extensively to measure cardiac output but has had limited application to regional flow. Following rapid venous or central injection of an indicator, successive curves of rising and falling indicator concentration are inscribed at an artery, representing initial circulation and recirculations. If the amount of indicator injected (I) is known, and if the area (A), which is the product of the average concentration (C) and the duration of the curve (T), is determined for the extrapolated semilogarithmic graph of the initial curve, then the flow (Q) is calculated from the following conventional formula:

$$Q = I/CT = I/A \qquad (1)$$

It follows that if, after central injection, the amount of indicator entering a given vessel were known, flow through that vessel could be calculated. Thus, for the vessel R:

$$I_R = Q_R C_R T_R \qquad (2a)$$

and

$$Q_R = I_R/A \qquad (2b)$$

where A is the area under the local curve ($C_R T_R$) or under any simultaneous peripheral dilution curve, all such areas being equal.

If R is the single afferent or efferent for a region, knowledge of I_R permits calculation of the regional flow. I_R is proportional to the unknown flow and has no other physiologic determinants. If, however, a natural or designed measurable supplement to Q_R produces a measurable alteration in A, solution is possible by means of simultaneous equations.

If any vessel or chamber V receives blood from several sources, among them the complete flow for region R, and if I_R is delivered prior to indicator I_X from other sources, an early curve, representing Q_R, will be inscribed, following mixing, at sites distal to V. The average concentration of the indicator (C_V) during inscription of this early curve is a function of the indicator (I_R) and the flow ($Q_R + Q_X$) that traverses V during the time interval T. Thus:

$$I_R/(Q_R + Q_X)T_V = C_V \qquad (3)$$

Combining Eqs. 2 and 3, we have:

$$Q_R A = (Q_R + Q_X) C_V T_V \qquad (4)$$

$C_V T_V$ is the area under the early curve. Therefore:

$$Q_R A = (Q_R + Q_X) A_V \qquad (5a)$$

or

$$Q_R = \frac{(Q_R + Q_X)}{A/A_V} = \frac{Q_X}{(A/A_V) - 1} \qquad (5b)$$

A is the area under a conventional arterial curve. Therefore, whenever a discrete A_V is obtained, the Q_R responsible for it can be quantified as a function of Q_X or of $Q_R + Q_X$. The latter, moreover, is a measurable quantity whenever V is a cardiac chamber, since $Q_R + Q_X$ must then become the output of one of the ventricles, and, in certain instances, Q_X may be a measurable fraction of a ventricular output. Thus, one can measure flows which empty into a cardiac chamber to produce a dilution curve distinct from those of general circulation and recirculation.

This principle is applicable to at least four systems:

1) With left-to-right shunts—through atrial septal defects, for example—shunted blood (Q_R) joins Q_X to produce pulmonary flow, which can be estimated from a peripheral arterial dilution curve after injection into the pulmonary artery, while Q_R produces an early curve from the right ventricle. The ratio of the area of the early right ventricular curve to the area of the systemic arterial curve equals the fraction of pulmonary flow traversing the shunt.

2) After proximal aortic injection, the earliest curve expected from the left ventricle, in the absence of valvular regurgitation, is that of the indicator completing its first circulation. However, physiologic shunts exist in the form of systemic-pulmonary (chiefly bronchopulmonary) communications through which a portion of the left ventricular output returns to the left atrium without traversing systemic great veins and the right heart. This pulmonary collateral flow (Q_R) plus right ventricular output (Q_X) equals systemic flow, which is estimated from the peripheral arterial dilution curve, while Q_R produces an early curve from the left ventricle. The ratio of the area of the early left ventricular curve to that of the systemic curve equals the fraction of the left ventricular output traversing pulmonary collateral channels.

3) The first indicator to appear at the pulmonary artery after left atrial injection should be that traversing the short, rapid, low-volume pathway through the coronary sinus into the right atrium. The systemic output is estimated from a peripheral arterial curve, while the early pulmonary artery curve is proportional to coronary sinus flow, and the ratio of the area of the latter curve to that of the former expresses coronary flow as a fraction of systemic output.

4) With mitral regurgitation the flows converging upon the left atrium are the forward flow (Q_X) and the backflow (Q_R). After left ventricular injection, the early curve from the left atrium will be proportional to Q_R, while the conventional systemic arterial curve will be proportional, not, as in the situations cited above, to the sum of Q_R and Q_X, but to Q_X alone, the forward flow. Since the measured general flow is a fraction of, and not the entire, ventricular output, the version of Eq. 5 required is that in which Q_R equals the general flow divided, not by the ratio of the general to the regional area, but by that ratio minus 1.

In addition, one can infuse Q_X exogenously, as a known volume, into the arterial inflow to any part. If, then, following central injection and mixing of the indicator, a turbulence exists at or distal to the infusion site sufficient to produce mixing between the arterial blood and the infusate, a collection downstream will reveal a proportionally altered dilution curve. The ratio of the area of the latter curve to that obtained at another peripheral vessel will give the fraction of systemic output traversing the local bed. This has obvious implications for measurement of flows in organs and limbs.

Although the early appearance of dye at sites upstream from the site of injection has been used qualitatively to detect the presence of left-to-right shunts and mitral regurgitation (*2*), quantification of these or of other flows by comparison of the areas of modified regional curves with general systemic curves has not, to our knowledge, been reported.

The practical applicability of this

principle has been established by us chiefly in the study of pulmonary collateral flow (*3*). The formula has made it possible to quantify observations of such flow made earlier by one of us (L. G.) at Yale University. Those investigations—the earliest in which this experimental design was applied to the study of a physiologic flow—have been extended in this laboratory to human subjects. In several instances we have measured total pulmonary collateral flow by this and an independent indirect method, with agreement between the two results. Our studies of shunt flows and of mitral regurgitation are in progress and are promising.

Since indicator dilution methods are not confined to cardiovascular physiology, it is conceivable that the principle here described will prove useful in other problems of flow measurement.

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21 August 1958

Function of Giant Mauthner's Neurons in the Lungfish

Abstract. Unit spikes were recorded from the spinal cord of the lungfish *Protopterus* and were identified with Mauthner's axon. With these spikes occurred nongraded tail flips suggesting startle responses. The tail flip and the giant spike resulted from certain forms of jarring and prodding. The conduction velocity for the slightly myelinated 45 μ diameter fibers was 18.5 m/sec.

The Mauthner's neurons of teleosts and urodeles have been the subject of many anatomical and embryological studies (*1*). Speculations about their function have had little physiological basis, and electrical recordings presumably from these neurons (*2–4*) have shed no real light on their normal role in the animal. Berkowitz (*4*) was the first to give some experimental grounds for assuming a special startle-response function in a carp, *Cyprinus,* and Retzlaff (*5*) reported comparable results which could be similarly interpreted. Berkowitz showed that physiological (tapping) stimulation of a certain type elicited sharp tail flips and high-velocity cord potentials, and that electrical stimulation of the cord just at the threshold point for such post potentials gave the same tail flip. The potentials were not all-or-none but presumably involved both Mauthner's and some other large fibers of the medial longitudinal fasciculus. Retzlaff recorded from what was doubtless the Mauthner's cell and saw similar tail jerks, but his results, obtained with semimicroelectrodes, do not permit the conclusion that the response is all-or-none activity in a single unit, though the Mauthner's spike and tail jerk were one-to-one. It seemed desirable to show more clearly whether a stereotyped, abrupt, maximal, twitchlike, normal movement is mediated by activity of the Mauthner's axon alone.

That *Protopterus* would be especially suitable for such experiments was suggested when Smith (*6*) called attention to the large size of the Mauthner's axons in this lungfish. In *Protopterus* this pair of fibers in the ventral columns of the spinal cord is truly giant and, therefore, may be expected to be accessible to selective electrical stimulation by virtue of a relatively low threshold and to single-fiber recording from the intact cord. The experiments described in this report (*7*) were performed on three 20- to 30-cm fish.

On the assumption that giant fibers mediate startle responses, attempts were made with various types of stimulation to produce sudden, single, stereotyped, large-magnitude movements. Individuals varied considerably in their responsiveness, but, although they were usually sluggish, all of them under some kinds of stimulation showed this type of reaction, confined to a sharp flexion of the tail. The response was produced by deep probing with a needle, by dropping the dish containing an animal onto the table, and by massive electrical stimulation of the body surface or of the exposed spinal cord. It occurred more readily in one specimen when the fish was placed on a dry surface. It was sometimes repetitive, alternating from side to side (compare Retzlaff's simultaneous stimulation of both VIIIth nerves). Weak vibration from a tuning fork, a jarring of the aquarium, strong light, or disturbances of spatial orientation failed to elicit the response.

Application of single electrical shocks to the dorsal surface of the spinal cord, above a sharp threshold, caused the same type of movement. The magnitude of the response to a single shock was nearly as great as that resulting from tetanizing frequencies. Electrical recordings from a second region of the cord showed two main components of activity following electrical stimulation. The first was a single all-or-none, sharp-threshold spike having an apparent conduction velocity of 18.5 m/sec (at about 20°C). The second was a complex wave which was graded in magnitude with respect to stimulus intensity and which was conducted at apparent velocities of between 4.1 and 1.3 m/sec. Spikes similar in form to the first wave were seen also during stimulation of the body surface by the same probing and electrical shock which had been found to give the startle response. These spikes were many times larger than any which occurred during ordinary locomotion and were always accompanied by the flip of the posterior trunk and tail described above.

The results indicate that the Mauthner's neuron in the lungfish, by itself, can mediate a special type of prompt, nongraded tail-flip response which may be compared with the startle response of many invertebrates possessing giant fibers (*8*).

The velocity of 18.5 m/sec is surprisingly low in comparison with the 35- to 40-m/sec velocity at 5°C (*5*) and the 50- to 60-m/sec velocity at 10° to 15°C (*2*) in *Ameiurus*—a fish in which Mauthner's fibers measure 22 to 43 μ in outside diameter—and with 80 m/sec (at 23°C) in *Parasilurus* (*3*) and 55 to 63 m/sec (at 20° to 25°C) in *Cyprinus*—fish in which Mauthner's fibers measure 55 to 65 μ (*4*). Random sections through the cord in the same specimens of *Protopterus* showed Mauthner's fibers of 45 μ in formalin-fixed preparations. These fibers had myelin sheaths accounting for no more than 3 percent of the total diameter, as compared with 50 percent in *Ameiurus* (*2*). There can be little doubt that the fiber stimulated and recorded from is Mauthner's, in view of the great discontinuity in size between it and the next largest fibers—a feature in which *Protopterus* stands out.

The large number of input sources to this cell which have been histologically identified appear to result in the simplest of outputs—one or a few impulses, or nothing. The most conspicuous source of input is vestibular, but simple displacement, tilting, or acceleration are apparently inadequate to fire the cell. The only physiological form of adequate stimulation found in these specimens, under the conditions of these experiments, was a severe jar. Possibly this represents an intense and synchronous activation of certain elements of the VIIIth nerve, similar to Retzlaff's electrical stimulation of the same nerve. By analogy with carp, earthworm, crayfish, and squid, it may be expected that under other conditions of set or readiness a much weaker stimulus would be adequate. It seems likely

that much of the input is integrated in such a way as to determine the probability of firing by certain limited sources or temporal patterns of impulses. Furthermore, the ratio of input to output impulses is probably very high and therefore insensitive to considerable fluctuations in absolute numbers of input impulses of the most active pathways.

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* Predoctoral fellow of the National Science Foundation.

15 September 1958

Thermal Decomposition of Rare Earth Fluoride Hydrates

Abstract. A thermogravimetric study of the thermal decomposition of La, Nd, Sm, Gd, Dy, Er, and Y fluoride hydrates shows that minimum dehydration temperatures are from 315° to 405°C; conversion of the fluorides to oxyfluorides begins in the 600° to 690°C temperature range.

As part of our investigations of the thermal decomposition of rare earth compounds (*1*), the pyrolysis of the rare earth fluoride hydrates was studied. The dehydration of these compounds is of interest at the present time because the anhydrous fluorides are used to prepare the rare earth metals.

Popov and Knudsen (*2*) previously studied the isothermal decomposition of the anhydrous rare earth fluorides and found that the pyrolysis took place in two steps. The first step was the conversion to the metal oxyfluoride; this was followed by the second step, the conversion of the oxyfluoride to the metal oxide. To our knowledge, the dehydration of the hydrated metal fluorides has not been described, and it is the subject of this report.

The rare earth fluorides were prepared by precipitation of the metal ions with aqueous hydrogen fluoride. The precipitated metal fluorides were filtered off through filter paper, washed with water, and air-dried for 24 hours at room temperature. Under these conditions, the metal fluorides corresponded approximately to the ½- or 1- forms of the hydrates.

An automatic recording thermobalance, previously described (*3*), was used to obtain the thermolysis curves. The samples ranged in weight from 90 to 100 mg and were run in duplicate or triplicate. A furnace heating rate of 5.4°C per minute was employed.

The thermograms of the rare earth fluoride hydrates are given in Fig. 1. From these curves and from previous studies (*2*), the following general pyrolysis pattern is presumed to take place:

$$MF_3 \cdot (\tfrac{1}{2} \text{ or } 1)H_2O \rightarrow MF_3 \rightarrow MOF$$

All of the compounds began to evolve water of hydration in the 40° to 60°C temperature range. However, horizontal weight levels corresponding to those of the anhydrous metal fluorides were obtained only for neodymium, samarium, and gadolinium. All of the other metal fluorides lost weight continuously throughout the entire thermogram.

The pyrolysis of the metal fluorides to the oxyfluorides began in the 600° to 690°C temperature range. The rates of pyrolysis were quite slow and did not result in the metal oxyfluoride weight levels even at 900°C. Since the upper limit of the thermobalance furnace is 900°C, the pyrolysis could not be extended to higher temperatures.

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2. A. I. Popov and G. E. Knudsen, *J. Am. Chem. Soc.* 76, 3921 (1954).
3. W. W. Wendlandt, *Anal. Chem.* 30, 56 (1958).

8 January 1959

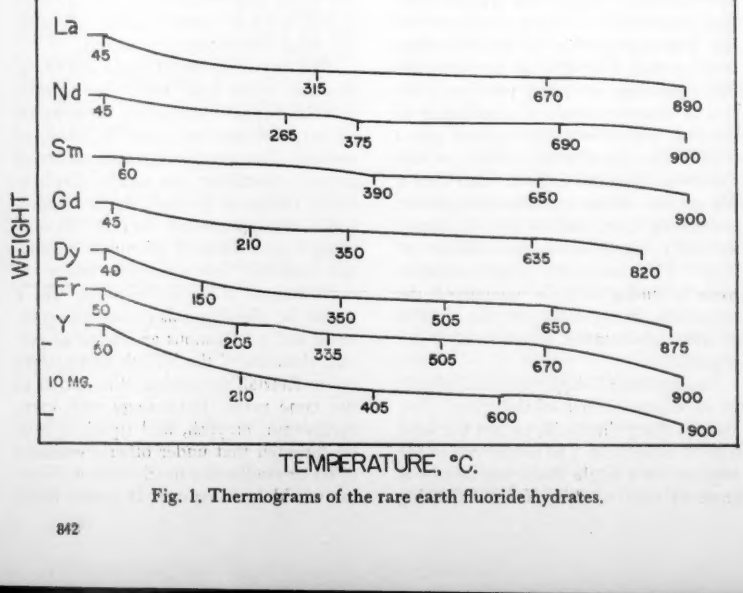

Fig. 1. Thermograms of the rare earth fluoride hydrates.

Transient Memory in Albino Rats

Abstract. Rats were trained on the repeated reversal of a position habit in a T-maze. Test trials of memory were given at varying intervals after the completion of each reversal. Those animals exhibiting a consistent preference for one side failed to retain the effects of training to the nonpreferred side for more than a few minutes.

Boycott and Young (*1*) have demonstrated the possible existence of reverberatory circuits mediating a discrimination habit in brain-damaged octopuses. The animals were preoperatively trained to attack a crab but to withhold the attacking response when the crab was presented along with a white card. If a response was made to the latter condition, the octopus was punished with an electric shock. Damage to certain parts of the brain eliminated the habit. The octopus attacked the crab under both conditions when trials were spaced by 2 or more hours. If, however, one negative trial (white card presentation) succeeded another within 5 minutes, the animal, correctly, withheld the response. Apparently the preceding negative trial had set up some short-term activity within a neural system corresponding to a memory trace of that trial which accounted for the absence of a response to the crab a few minutes later. The subsidence of this neural activity would explain the reappearance of the attacking response after an interval of 2 hours.

The present experiment reveals a similar transient memory in albino rats, but under a different set of conditions. Normal rats and rats subjected to either cortical or subcortical damage were trained on a simple water T-maze. Prior

to this experiment, all animals were given considerable experience in the maze. For 12 days, each rat was trained to go to the arm of the T that was incorrect on the immediately preceding day. A ladder was provided at the end of the correct alley which allowed the animal to climb onto a drying platform. If an error was made, the animal had to swim back to the choice-point and choose the other arm of the T. Training to the correct side was continued until the animal reached the criterion of three errorless responses within a series of four trials. During training, the intertrial interval was 30 seconds. Each day the animal was given one test trial 1 minute, 1 hour, and 5 hours, respectively, after it met the criterion. During these three daily test trials of memory, the ladder was placed in the arm which was correct for that particular day.

Table 1 presents the individual mean error scores in learning to go to the preferred and to the nonpreferred positions (*2*). Also included for each animal is the total number of correct responses made on the test trials at each interval, the maximum being six correct responses for each position. Transient memory is clearly revealed in those rats which were performing under a strong position habit: those which made significantly more errors learning to go to one side (that is, left) than to the other (that is, right).

It can be seen that when training was to the nonpreferred side, the animal retained the effects of training for 1 minute, but not after 1 or 5 hours. Among the eight animals which showed a significant preference, performance on the 1- and 5-hour test trials was very reliably higher when the preferred side was correct than when it was incorrect. No such differences were apparent for the animals not operating under a significant position habit. Of the 11 operated animals, six revealed the phenomenon of transient memory. Additional animals have since been run, and it has been found that approximately 50 percent of all the operated animals display a strong position habit; of these, all showed transient memory of the effects of training to the nonpreferred side. Normal rats also reveal position habits, but the frequency of strong position habits is considerably smaller. Table 1 shows data for two such normal rats (No. 1 and No. 5) which exhibited poor memory of training to the nonpreferred position. These transient memories obviously are not a function of surgical brain damage.

This phenomenon strongly supports the view that the neutral memory trace passes through an initial reverberatory state followed by a more permanent structural state. In this experiment, massed training to the nonpreferred side apparently initiates activity within a neural system which inhibits the response to the preferred side. This activity, at the same time, produces a structural trace having the effect of strengthening the response tendency to the nonpreferred side. The activity of the system, however, subsides within a few minutes, leaving only the newly formed structural trace. Since a strong preference previously existed for the opposite side, the strength of the new trace is not as great as that corresponding to the preferred side. Thus, a test trial given 1 hour after training would result in a response to the preferred position. If, however, the test-trial is given a few minutes after training, the neural system is still active and permits a response to the nonpreferred position. In those animals not exhibiting a strong position habit, a similar sequence of events occurs. But the reason that the animals respond successfully 1 hour after training is that the structural trace left by the previously active system is of greater strength than that corresponding to the other side.

That this interpretation seems to be the correct one is indicated by two lines of evidence. First, a position habit can be eliminated by special training to the nonpreferred side. This was done for those animals exhibiting a position habit (see Table 1). All animals except one (animal 18), were subsequently able to perform significantly better on the 1- and 5-hour memory tests after training to the formerly nonpreferred position. In the second place, with a more stringent criterion of learning (six errorless responses within a series of seven trials), performance on the 1-hour test trials significantly increased, although the position habit in some cases still existed.

To what extent a similarity exists between these data and those of Boycott and Young is difficult to say. Boycott and Young concluded that brain damage to the vertical and frontal lobes somehow seriously affected the permanent memory system of the octopus. Our results suggest the interpretation that damage to these areas may have intensified the attacking tendency of the octopus, possibly by releasing an inhibitory mechanism. Thus, the octopuses would more readily attack the food and behave like rats that have a strong position habit.

In any event, the data of this experiment demonstrate that habit tendencies acquired by massed practice can be maintained by temporary active neural systems, probably reverberatory circuits, and that the amnesic effect of discrete subcortical stimulation may be due to the disruption of this activity (*3*).

Table 1. Mean errors to criterion and total number of correct responses on test trials for each position.

Rat No.	Principal damage	Preferred				Nonpreferred			
		Learning	1 min	1 hr	5 hr	Learning	1 min	1 hr	5 hr
18*	Subrhinal cortex	2.0	6	6	6	7.5	4	0	1
26*	Tegmentum	0.3	6	6	6	4.6	3	0	0
25*	Superior colliculus	0	6	6	6	5.0	4	0	0
23*	Posterior cortex	1.0	6	6	6	6.3	4	2	0
27*	Subrhinal cortex	0.3	6	6	6	4.8	4	2	0
2*	Anterior cortex	0.6	6	6	6	2.0	5	2	0
6	Subrhinal cortex	2.5	5	5	4	2.5	6	5	5
9	Hippocampus	3.6	5	5	5	6.5	4	6	4
10	Amygdala	1.0	6	6	6	4.3	5	6	6
20	Caudate	1.3	5	6	6	1.6	6	5	5
33	Posterior cortex	2.6	6	6	4	3.5	5	5	6
1*	None	0.3	5	6	6	2.7	4	0	0
5*	None	0	6	6	6	1.5	6	0	0
34	None	0.3	6	6	5	1.0	6	6	6
35	None	0.5	6	4	5	0.5	6	5	5
36	None	0.5	6	6	5	0.5	5	5	5

* The animal showed a statistically significant preference for one side.

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2. The original purpose of this experiment was to determine the effects of cortical and subcortical lesions on memory. The appearance of the transient memory effect, however, did not require the use of operated rats. These rats are included within the results because they show a greater frequency of position habits than normal rats.
3. R. Thompson, *J. Comp. and Physiol. Psychol.* 51, 421 (1958).

18 August 1958

Depression of Norepinephrine and 5-Hydroxytryptamine in the Brain by Benzoquinolizine Derivatives

Abstract. The effects of two benzoquinolizine derivatives on the 5-hydroxytryptamine and norepinephrine content of the brain of mice, and some pharmacological actions, are described. Certain central effects (such as sedation and narcosis potentiation) of benzoquinolizine derivatives and possibly of *Rauwolfia* alkaloids may be due to changes of norepinephrine metabolism rather than to changes of 5-hydroxytryptamine metabolism in the brain.

Reserpine and certain benzoquinolizine derivatives cause a marked depression of norepinephrine and 5-hydroxytryptamine levels in the brain of various animal species (*1*). The effects include sedation as well as potentiation of ethanol and barbiturate narcosis. It has been postulated that a causal connection exists between the pharmacological action of the afore-mentioned drugs on the central nervous system and their influence on monoamine metabolism (*2*). However, it is difficult to determine which change in the endogenous monoamines in the brain (norepinephrine or 5-hydroxytryptamine) is more important for the central effects of the drugs.

The benzoquinolizine derivatives investigated up to now have had almost equal effects, with regard to amount of depletion and duration of action, on norepinephrine and 5-hydroxytryptamine in the brain. Certain *Rauwolfia* alkaloids cause more marked norepinephrine than 5-hydroxytryptamine depression (*3*). Experiments with 3,4-dihydroxyphenylalanine and 5-hydroxytryptophan in animals pretreated with reserpine suggested that changes in norepinephrine levels might be more important than changes in 5-hydroxytryptamine levels (*4*).

Recently two benzoquinolizine derivatives (Fig. 1) (*5*) have been found to affect the brain content of 5-hydroxytryptamine in mice almost equally but the brain content of norepinephrine differently (Fig. 2). The average dose necessary to depress the 5-hydroxytryptamine content to about 50 percent of its original value (ED_{50}) was 2 mg/kg for compound I and 3 mg/kg for compound II. Maximum 5-hydroxytryptamine depression was reached in 1 hour, full recovery in about 6 hours, after administration of either of the compounds. The norepinephrine content, however, became markedly more depressed after administration of compound I than it did after administration of compound II. The ED_{50} for norepinephrine depression was about 5 times higher for compound II than for compound I.

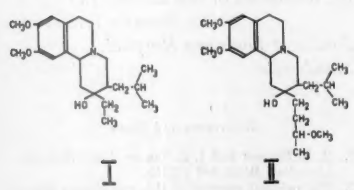

Fig. 1. Benzoquinolizine derivatives.

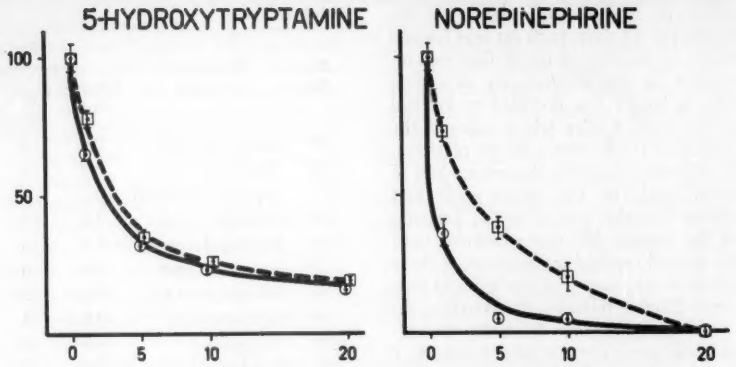

Fig. 2. 5-Hydroxytryptamine and norepinephrine content of the brains of mice after intraperitoneal administration of the benzoquinolizine derivatives I and II. Abscissa: dose (in milligrams per kilogram); ordinate: 5-hydroxytryptamine and norepinephrine content, respectively, as percentage of controls; solid lines, compound I; dotted lines, compound II. Each point represents the average of 6 to 27 determinations. For each determination the brains of five mice were pooled. Vertical lines, standard deviation. 5-Hydroxytryptamine and norepinephrine were determined by spectrophotofluorometric methods (*6*). The oxidation of norepinephrine was carried out with potassium ferricyanide. The blanks consisted of half the final extracts of each sample; no ascorbic acid was added before addition of the potassium ferricyanide. In the 5-hydroxytryptamine method only a reagent blank—no tissue blank—was subtracted. Interference of compounds I and II with the fluorescence of 5-hydroxytryptamine and norepinephrine could be excluded by experiments in which the compounds were added to the brain homogenates.

The pharmacological action of compounds I and II on the central nervous system of mice was also different. Compound I, in doses between 1 and 5 mg/kg, had a marked sedative effect. Furthermore, 5 mg of compound I per kilogram, injected 1 hour prior to administration of 4 g of ethanol per kilogram, prolonged the sleeping time to 110 ± 12 minutes. After administration of ethanol alone (4 g/kg) the average duration of sleep was 1 minute. A dose of 5 mg of compound II per kilogram had but a slight sedative effect. The period of ethanol-induced sleep was prolonged to 7 ± 3 minutes only.

Thus the pharmacological effects of compounds I and II on the central nervous system may possibly be related to the depression of norepinephrine but probably not to that of 5-hydroxytrptamine.

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3. M. K. Paasonen and P. B. Dews, *Brit. J. Pharmacol.* 13, 84 (1958); M. K. Paasonen, personal communication.
4. A. Carlsson, M. Lindquist, T. Magnusson, *Nature* 180, 1200 (1957).
5. The benzoquinolizines used in this study were synthesized by Dr. A. Brossi of the chemical research department of F. Hoffmann-La Roche & Co. Ltd., Basle, Switzerland.
6. D. F. Bogdanski, A. Pletscher, B. B. Brodie, S. Udenfriend, *J. Pharmacol. Exptl. Therap.* 117, 82 (1956); P. A. Shore and J. S. Olin, *ibid.* 122, 295 (1958).

8 September 1958

Meetings

International Astronomical Union

The tenth general assembly of the International Astronomical Union was held at Moscow, in the building of Moscow University, from 12 to 20 August 1958. According to the printed list there were 832 delegates and 258 guests.

The handling of this large meeting by our Russian hosts was marked by great generosity. The delegates' meals and lodgings, at the newest hotel in Moscow, were paid for by the Soviet Government. Transportation to the meetings was provided, as well as transportation for numerous trips to museums and art institutes. For the general meetings and the formal symposia, a translation service was provided like that at the United Nations, complete with interpreters in booths and small individual radios, with switches for French, English, and Russian, to be hung around the neck.

More important than any of these was the cordial hospitality which was shown by all of the Russians with whom the astronomers came in contact—the little clerk at the Lenin Library, who went dashing away to run down a book and came back apologizing for her poor English; the cheerful assistant who handed out books and earphones at the desk as if her life depended on it, and who turned out to be a world authority on the making of artificial diamonds; the kind professor, still showing visitors around his institute two hours after closing time. At no time were the political frictions outside evident in the Assembly proceedings or in the bearing or speech of our hosts.

The fundamental framework of the union is a system of 40-odd commissions and subcommissions, whose primary function is to coordinate the work of the observatories. The best example of such coordination is in the field of the national ephemerides. The work of preparing these has been parcelled out all over the world with such effectiveness that there is now relatively little duplication of computing effort, and most of the world accepts identical texts, with minor or major national embellishments.

In less well-regulated fields, the commissions serve to promote the standardization of notations and the launching of international programs of cooperation (especially in the fields of positional astronomy), to make possible international comparison of progress.

At the tenth assembly, the work of the commissions was somewhat hindered by the trilingual character of the meetings. By contrast with the ninth (Dublin) assembly—when most of the commissions adopted English, a few adopted French, and the assembly then proceeded in the adopted language—this assembly proceeded in three languages in almost all of the commissions. Since the apparatus of interpreters and radios was too expensive to be used for anything except the meetings and symposia of the assembly as a whole, the translations were necessarily given after the original speech. It inevitably followed that only one-third as much could be said. In the case of very well-run commissions, where the meeting had to deal only with problems thoroughly prepared in advance, this situation served to curb the more voluble, and a satisfactory number of decisions could be made. In other cases, a minor issue—even an issue of names—could seriously delay the whole commission, as the problem was thrashed out in English, French, and Russian.

There were several very successful symposia at the assembly. One of these was on the origin of the solar system; it was conducted very informally by B. J. Levin, and it actually brought Urey, Kuiper, Jeffreys, Hoyle, Levin himself, and others to their feet in face-to-face arguments. The symposium greatly illuminated the real problem—namely, how to account for the fact that the sun rotates so slowly that almost all of the angular momentum of the solar system is in the planets, which have so little (0.1%) of the mass. The symposium also underlined the significance of condensation to the solid state for the process of planet formation.

A second successful symposium, also unofficial, was held, with Sadler in the chair, on the applications of observations of the moon and artificial satellites to the problems of positional astronomy and geodesy. The most interesting result of the meeting was independent agreement by Czech, British, and two American groups on the fact that the motion of the nodes of the satellites indicates a value for the earth's oblateness, which is very significantly different from the hydrostatic value. This was in the nature of a personal triumph for Sir Harold Jeffreys, who has long maintained that the earth's interior is not in hydrostatic equilibrium and that the layers beneath the crust are not plastic, even under very long-continued stresses—that they possess ordinary, though limited, mechanical strength.

A group of three official symposia treated the problem of the origin of the elements and the related question of the internal constitution and history of the stars as these are revealed by the Hertzsprung-Russell diagram (a plot of absolute magnitude against spectral type or color). The first section treated the observations of the H-R diagram; the second, the theory; and the third, the problems of nuclear formation. These symposia were not as successful as the informal symposia. They were held in

the large conference room, and simultaneous translations were provided. Unfortunately, the first speech was filled with references to a set of diagrams which the delegates were supposed to, but did not, have before them, and several of the later speeches left the interpreters in stuttering incoherence or helpless silence while the speaker raced on.

In the last symposium of this group, the question of the origin of the elements was directly attacked. The advocates of origin in stellar interiors (including those of supernovae) directly confronted the advocates of origin from an initial explosion. Both parties agreed that many of our present stars are not composed of virgin material, but are partly made up of recondensed ejecta from earlier stars.

With regard to the meeting arrangements, it was somewhat unfortunate, from the point of view of informal contacts, that the U.S. delegation was assigned dining rooms separate from the other delegations. This kind of problem is the inevitable result of the size of the meeting. The new president, J. H. Oort, of Holland, addressed himself to the task of reconstructing the union, by subdividing it, to restore its earlier informality and intimacy. In the meantime, it should be recognized that this meeting made a notable contribution in bringing together scientists from the Communist and non-Communist worlds, and that its success was due to the efforts of the individual Russians.

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Extending the Parabola

The Institute of General Semantics, Lakeville, Conn., has announced that the Alfred Korzybski Memorial Symposium will be held on 11 April in New York at the Carnegie International Center, 345 E. 46 St. The theme will be "Extending the Parabola," and addresses on new frontiers in biophysics, space science, neurology, and psychology will be delivered by William J. Fry of the University of Illinois, James A. Van Allen of the State University of Iowa, Charles M. Pomerat of the University of Texas (Galveston), and Wendell Johnson and Russell Meyers of the State University of Iowa.

Millimeter Waves

Scientists and engineers from England, France, Israel, Japan, the Netherlands, and the U.S.S.R. will take part in an international symposium on Millimeter Waves on 31 March–2 April in the auditorium of the Engineering Societies Building, 33 W. 39th St., New York. The program of invited papers has been designed to permit research scientists working in the fields of solid state, microwave theory and techniques, electron tubes, and plasmas to take part in the exchange of information on progress and plans for the future in the generation and application of millimeter waves in physics and communications.

Arranged by the Microwave Research Institute of the Polytechnic Institute of Brooklyn in cooperation with the Institute of Radio Engineers, the symposium is cosponsored by the Air Force Office of Scientific Research, the U.S. Army Signal Corps, and the Office of Naval Research. As at past symposia, there will be no registration or admission fee. Further information is available from Polytechnic's Microwave Research Institute, 55 Johnson St., Brooklyn 1, N.Y.

Operations Research

Specialists in information and decision theory and other closely related topics in operations research will speak at the second annual Symposium on Information and Decision Processes to be held at Purdue University on 15–17 April. The purpose of this symposium, according to Paul R. Randolph of Purdue, chairman of the symposium committee, is to acquaint individuals who are working in applied areas in industry with the research work in information and decision theory. Particular emphasis will be on the significance of this work to problems of research and development in industry and government.

Topics to be covered will include the latest work on inventory control, reliability, consistency of models, stocastic processes, computer logic, and linear and dynamic programming. Further information may be obtained from Dr. Paul H. Randolph, Engineering Administration Building, Purdue University, Lafayette, Ind.

Forthcoming Events

April

27–28. Society of Exploration Geophysicists, 12th anunal midwestern exploration, El Paso, Tex. (D. Dawson, Dawson Geophysical Co., Midland, Tex.)

27–28. Society of Neurological Surgeons, New York, N.Y. (B. S. Ray, 525 E. 68 St., New York 21.)

27–29. Aero Medical Assoc., Los Angeles, Calif. (T. H. Sutherland, P.O. Box 26, Marion, Ohio.)

27–30. Physical Chemistry of Extractive Metallurgy, intern. symp., Pittsburgh, Pa. (AIME, 29 W. 39 St., New York 18, N.Y.)

27–30. Physical Chemistry of Process

Metallurgy, intern. symp., Pittsburgh, Pa. (J. F. Elliott, Room 8-109, Massachusetts Inst. of Technology, Cambridge 39.)

27–1. American Psychiatric Assoc., Philadelphia, Pa. (C. H. Hardin Branch, 156 Westminister Ave., Salt Lake City, Utah.)

29–1. American Inst. of Electrical Engineers, Syracuse, N.Y. (N. S. Hibshman, AIEE, 33 W. 39th St., New York 18.)

30–1. Eastern States Health Education Conf., New York, N.Y. (I. Galdston, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

30–1. Youth Conference on the Atom, 1st natl., Atlantic City, N.J. (W. Adams, Bozell & Jacobs, Inc., 2 W. 45 St., New York 36.)

30–2. American Assoc. for Cleft Palate Rehabilitation, Philadelphia, Pa. (D. C. Spriestersbach, University Hospitals, Iowa City, Iowa.)

30–2. American Goiter Assoc., Chicago, Ill. (J. C. McClintock, 149½ Washington Ave., Albany, N.Y.)

30–2. American Physical Soc., Washington, D.C. (K. K. Darrow, Columbia Univ., New York 27, N.Y.)

30–2. Eastern College Science Conf., 13th annual, Boston, Mass. (A. F. Lett, ECSC, Suffolk Univ., Boston 14)

30–2. Kansas Acad. of Sciences, Lawrence. (J. O. Harris, Kansas State College, Manhattan.)

30–3. Student American Medical Assoc., Chicago, Ill. (R. F. Staudacher, 430 N. Michigan, Chicago 11.)

30–4. American Assoc. for the Study of Neoplastic Diseases, Gatlinburg, Tenn. (B. H. Sisler, Box 268, Gatlinburg.)

May

1–3. Prevention of Bacterial Resistance to Antibiotics, intern. sypm., Perugia, Italy. (Segreteria del Simposio, Clinica Ostetrica e Ginecologica, Policlinico, Perugia.)

2. Idaho Acad. of Science, Moscow. (E. J. Larrison, Sec.-Treas., Dept. of Biological Sciences, Univ. of Idaho, Moscow.)

2–3. American Psychosomatic Soc., 16th annual, Atlantic City, N.J. (M. Rosenbaum, APS, 265 Nassau Rd., Roosevelt, N.Y.)

2–7. Experimental Biology, intern. symp. (celebration of Lazzaro Spallanzani), Reggio and Pavia, Italy. (C. Jucci, Director, Istituti di Zoologia L. Spallonzani, Universita-Pavia, Palazzo Botta, Pavia, Italy.)

2–9. International Union for Health Education of the Public, 4th conf., Dusseldorf, Germany. (M. L. Viborel, 92, rue St. Denis, Paris 1e, France.)

3. American Federation for Clinical Research, annual, Atlantic City, N.J. (G. E. Schreiner, Georgetown Univ. Medical Center, Washington 7.)

3. Periapical Lesions-Pacific Coast Oral Pathology Workshop, 1st annual, Los Angeles, Calif. (W. Bullock, Dept. of Pathology, Univ. of Southern California School of Medicine, 1200 N. State St., Los Angeles.)

3–7. American Assoc. of Cereal Chemists, 44th annual, Washington, D.C. (J. W. Pence, AACC, Western Utilization Research Laboratories, Albany, Calif.)

(See issue of 20 March for comprehensive list)

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 854.*

■ MILLIVOLTMETER INDICATOR is a servo-driven potentiometer with accuracy guaranteed by the manufacturer to be ±0.1 percent. The slide-wire of the instrument is 144 in. long and may be linear or nonlinear with equal accuracy. A Zener voltage reference is used. Display is provided alternatively by a calibration printed on a tape carrying the slide-wire or by a digital in-line counter geared to the slide-wire drive. For use with thermocouples the instrument is provided with automatic cold-junction compensation. Provision has been made for inclusion of binary and decimal contact-making counters to actuate digital recorders. Provision has also been made for addition of a retransmitting slide-wire as a signal source for auxiliary devices. (B & H Instrument Co., Dept. 708)

■ VACUUM SYSTEM COMPONENTS offered as building blocks for 4-in. vacuum systems include a stainless-steel cold trap and a nickel-plated baffle. The trap operates 8 to 10 hr on one 0.6-lit. filling of liquid nitrogen. The baffle includes cooling coils on the baffle disk and an external coil on the baffle shell. (Veeco Vacuum Corp., Dept. 693)

■ OSCILLOGRAM SCANNER accepts strips up to 1000 ft long, displaying 66-in. lengths at one time. Record traverse speed can be adjusted to a maximum of 100 ft/min. The illuminated scanning surface and the transport mechanism may be set at any convenient angle. Reading heads yielding digital or analog outputs are available. (Gerber Scientific Instrument Co., Dept. 706)

■ RESISTANCE WELDING HEAD designed for ultrafine welding—for example, joining gold-gallium wire to Kovar, platinum filaments to posts, and aluminum foil to itself—occupies 4¼ in. of bench space. Electrode pressure is adjustable between 4 oz and 15 lb. Maximum capacity is 80 watt sec. The head is operated by a foot pedal. (Weldmatic, Dept. 707)

■ PULSE GENERATOR provides repetition rates from 20 cy to 2 Mcy/sec and may be triggered externally. Pulse width is variable from 0.05 to 1000 μsec, pulse delay from 0 to 10,000 μsec. Pulse amplitude is 5 v positive or negative into a 50 ohm load. Rise and fall time is 0.02 μsec. (Rutherford Electronics Co., Dept. 696)

■ MULTIPLIER PHOTOTUBES newly available comprise one 15-stage, five 11-stage and two 10-stage tubes. All have maximum spectral response in the blue/violet region (4000 to 4200 A); two are fitted with quartz windows to allow adequate response to ultraviolet radiation. The tubes are designed for end-on viewing and have cesium-antimony photocathodes, ranging from 20 to 111 mm in useful diameter, with optically flat and parallel surfaces. (Mullard Ltd., Dept. 720)

■ OPTICAL PICKUP contains a phototransistor, a light source, and a lens system. The pickup detects, by reflection, graduations placed on a moving surface whose rotational or linear speed is to be measured. Pressure-sensitive adhesive film printed with lines is available for application to shafts or other surfaces. Indicators are available to cover ranges from 0.1 to 10^6 rev/min (full scale) with 1 percent accuracy. (Southwestern Industrial Electronics Co., Dept. 718)

■ DIGITAL VOLTMETER features sensitivity of 100 μv for d-c and 1 mv for a-c. The difference between a reference voltage and the signal voltage is detected by a chopper and applied, after amplification, to a stepping switch that adjusts the tap on the reference-voltage potentiometer. Four digits and a decimal point are displayed. Input impedance at null

is 10 megohm for d-c and 10 megohm and 20 μμf for a-c. Accuracy is ±0.01 percent ±1 digit for d-c and ±0.1 percent or ± 2 mv for a-c. Average balance time for d-c is 1 sec; for a-c, 3 sec. (Kin Tel, Dept. 684)

■ FUNCTION FITTER is a self-contained analog computing component for the simulation of arbitrary functions. It features ten straight-line segments with adjustable tangent parabolic rounding and adjustable slopes, break points, and offset. Incremental slopes are adjustable over a range greater than ± 10:1. George A. Philbrick Researches, Inc., Dept. 709)

■ MELTING POINT APPARATUS provides rapid heating to approach within 5° or 10°C of the melting point and a slower rate for observation of the melting-point temperature. Cooling from 300° to 100°C without compressed air requires 10 min; with compressed air, it requires 4 min. (Arthur S. LaPine & Co., Dept. 724)

■ CURRENT-PULSE GENERATOR produces pulses with rise times as short as 5 mμsec and with durations of 10, 20, 50, and 100 mμsec. Pulse amplitudes are adjustable from 0 to more than 2 amp. Pulse repetition frequency is adjustable from 100 to 10,000 per second. The generator may also be triggered from an external source or from a panel pushbutton. A synchronizing pulse is produced 5 mμsec before the current pulse output occurs. (Rese Engineering Inc., Dept. 717)

■ FAST-NEUTRON SURVEY METER operates on the proton-recoil scintillation principle. The instrument measures energy flux density in three ranges from 0 to 7.5 mrem/hr to 0 to 750 mrem/hr. The detector is a hollow polyethylene sphere coated on the inside with ZnS phosphor. A 5819 multiplier phototube penetrates the sphere to detect the scintillation pulses. (National Radiac, Inc., Dept. 722)

JOSHUA STERN

National Bureau of Standards, Washington, D.C.

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of box number counts as 10 additional words. Payment in advance is required. **Positions Open,** $33 per inch or fraction thereof. No charge for box number.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

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Single insertion	**$33.00 per inch**
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7 times in 1 year	**28.00 per inch**
13 times in 1 year	**27.00 per inch**
26 times in 1 year	**26.00 per inch**
52 times in 1 year	**25.00 per inch**

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Replies to blind ads should be addressed as follows:

Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Biologist, Ph.D., with teaching and research experience desires position. Interested in microbiology, bacteriology, parasitology, general biological science, and general biology. Prefers small or medium-sized institution. Box 67, SCIENCE. X

M.D., Ph.D. (physiology), 32. American, married, now completing internship, desires career in postclinical investigation. Broad interests; would enjoy some teaching. No military obligations. Box 56, SCIENCE. 3/20, 27; 4/3

Physiologist; Ph.D.; recommended as outstanding student, enthusiastic and competent researcher, interested and successful teacher. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

Scientific Photographer, medical illustrator, supervising and teaching x-rays in six languages; long experience in all fields, desires change (position in science, education, industry). Excellent background, best references. Write Box 64, SCIENCE. 4/3

POSITIONS WANTED

Psychologist, Ph.D., 5 years varied experience seeks research, clinical or academic position in New York City area. Box 65, SCIENCE. 4/3

Zoologist. Interests: invertebrates, limnology, parasitology. Teaching experience; publications; pre- and postdoctoral fellowships. Desires academic or research position. Box 66, SCIENCE. X

POSITIONS OPEN

Assistant to Director of Research for expanding company in the East. Outstanding opportunity for scientist who prefers administrative work. Would be responsible for business aspects of a growing research division. Ph.D. or equivalent desirable. Experience in original laboratory work essential, preferably in pharmaceutical industry. Send résumé of education and experience. Box 68, SCIENCE. 4/3

BACTERIOLOGIST
Research

An interesting position is open for a man or woman with a bachelor's degree in bacteriology and from 2 to 4 years' research experience.

This position offers an opportunity to use your initiative and creative ability. Excellent employee benefits and liberal vacation policy. Please send résumé to

E. P. Bloch

ARMOUR RESEARCH FOUNDATION of Illinois Institute of Technology

10 West 35 Street, Chicago 16, Illinois

Botanist-Bacteriologist. Ph.D. or equivalent, to teach bacteriology and some botany. Rank of assistant professor. Write Professor W. B. Stallworthy, Department of Biology, Mount Allison University, Sackville, New Brunswick, Canada. ew tf

Graduate Assistantships and Fellowships for teaching or research in biochemistry and entomology. Salary $2000 up for 11-month appointment. Research applicable toward M.S. or Ph.D. thesis. Send particulars to Vernon H. Cheldelin, Science Research Institute, Oregon State College, Corvallis. 3/20

POSITIONS OPEN

Instructor or Assistant Professor for general education course in physical science, and same for general education course in biology. Start September 1959, 9-month salary $5000 or $6000. Ph.D. and Ed.D. desired, or person with master's degree and exceptionally high other qualifications. Instructors can study part time, earn doctorate here. Write or send credentials to General Studies Department, Kansas State College, Manhattan, Kansas. X

(a) Internist, trained or experienced, cardiovascular field, certified or eligible; will consider Diplomate without cardiovascular training with interest in this field; one of leading pharmaceutical companies, East; starting salary $15,000. (b) Microbiologist, preferably with master's degree; duties consist of microbiological research on coal and related materials at company's laboratory located in suburb just south of large city, university medical center; East. (c) Biochemist, serve as chief, research biochemical laboratories; preferably Ph.D. or M.S.; clinic staffed by 25 specialists prominent in their fields; separate research laboratory now doing blood iodine and other endocrine hormone tests; Midwest. S3-4 Medical Bureau, Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

Man wanted to cover selected and profitable territory for specialty firm in Midwest. Must have some laboratory background and desire to sell. Products now servicing more than 11,000 laboratories in the United States providing a positive labeling system for laboratories and institutions. Box 60, SCIENCE. 4/10, 24; 5/8, 22

MATHEMATICIANS-GEODESISTS

Able to translate Russian; full time. State experience and salary desired.

Box S195, 125 West 41 Street
New York, N.Y.

MICROBIOLOGIST

Challenging position as a supervisor working on the development of microbiological assays for vitamins and antibiotics. Applicant should have B.S. or M.S. in microbiology with 2 to 5 years of related industrial experience. Excellent facilities in the Brooklyn Biological Control Laboratories. Send résumé to:

R. J. Taylor
Chas. Pfizer & Co., Inc.
11 Bartlett Street
Brooklyn 6, New York

New World-Wide Graduate Award Directories for American scientists, teachers, librarians to subsidize their education and research. Stipends $200–$10,000. Volume I (1957), $3; volume II (just published, no duplication), $3; both volumes, $5. Limited editions. Complete, specific information on 400 awards in United States and overseas in each volume. CRUSADE, Sci., Box 99, Station G, Brooklyn 22, N.Y. eow

Postdoctoral Traineeship in Cardiovascular Research. Supported by National Heart Institute and American Heart Association. July 1959 to June 1960. Stipend $3800 plus. For details write Dr. W. F. Hamilton, Medical College of Georgia, Augusta, Georgia. 4/3

SCIENCE TEACHERS, LIBRARIANS, ADMINISTRATORS urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue, $1.00. Yearly (12 issues) membership, $5.00. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

UNIVERSIDAD NACIONAL DEL SUR
Bahia Blanca, Argentina

Applications are invited for the position of director of the Institute of Soil Science and Hydrology. Engagement by contract for from 3 to 5 years. Salary to be arranged according to qualifications. Background in soil science required. Applications are also invited from scientists in the following fields: (i) physical chemistry of soils; (ii) chemistry of soils; (iii) soil classification; and (iv) soil microbiology. 4/3, 10

POSITIONS OPEN

HARVARD MEDICAL SCHOOL—BOSTON
Career Opportunity for Research Chemist (Female)

Harvard position at Massachusetts General Hospital. Head chemist with previous research experience to coordinate the work in a surgical research laboratory. Supervise eight junior research assistants. Four weeks' vacation. Excellent health and pension plans. $4000–$5500 depending on experience.

Write Personnel Office, Harvard Medical School, 25 Shattuck Street, Boston. Many other excellent opportunities for both experienced and beginning female chemists.

POSITIONS OPEN

SENIOR SCIENTIFIC WRITER

Pharmacologist with good chemical background and demonstrated writing ability to fill an available position. This is an opportunity to do interpretive writing with a minimum of guidance. It requires a person with solid experimental experience, an inquisitive mind, interest in semantical problems, ability to work with a group and a demonstrated capacity with written expression. Write

Box 63, SCIENCE

USE THIS EASY SELF-MAILER to obtain further information

27 March 1959

Readers' Service

Information Requisition

It's simple: Mark—Clip—Fold—Mail—No stamp required

This coupon is for your convenience—to facilitate your requests for further information about advertised products and items in Equipment.

From:

Name ..... Position .....

Company .....

Street .....

City ..... Zone ..... State .....
(Please print or type)

Mark, clip coupon—FOLD HERE along this line—mail

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
First Class Permit #12711 New York, N.Y.

Readers' Service

To: SCIENCE MAGAZINE
Room 740
11 West 42 Street
New York 36, New York

Fasten Here Only
Staple, Tape, Glue

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

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Single insertion	**$26.00 per inch**
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26 times in 1 year	**23.00 per inch**
52 times in 1 year	**22.00 per inch**

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FOOD and DRUG INDUSTRIES
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are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

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Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. **Abrahams Magazine Service; N. Y. 3, N. Y.**

FLUORIDATION AS A PUBLIC HEALTH MEASURE

Editor: James H. Shaw

Price $4.50, AAAS Members' prepaid order price $4.00

240 pp., 24 illus., index, clothbound, 1954

This volume offers a comprehensive consideration of the present knowledge of the relation of fluoride ingestion to human health. The eminent qualifications of each of the 21 authors should inspire confidence in the unbiased authenticity of the contents.

AAAS
1515 Mass Ave., NW, Washington 5, D.C.

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BACTERIOLOGICAL AND GROSS TISSUE STUDY TECHNIQUES USED IN OUR QUALITY CONTROL

HUNTINGDON FARMS, INC.
2548 NORTH 27th ST. PHILA. 32, PA.

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other High Radiopurity tagged compounds

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F. J. ZEEHANDELAAR Inc.
Wild Animal Importers
286 Clove Road,
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We import specially required livestock from any part of the world for research purposes.

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Electroencephalograph
Price $575.00 complete.
No Batteries
Requires no Shielding
Prompt Delivery
A.C. Operated
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ELECTRO-MEDICAL LABORATORY, INC.
South Woodstock 2, Vermont

1919 - 1959
LaMotte Chemical
Chestertown, Maryland, U.S.A.
Specialists in
Colorimetric Techniques
Reagents-Standards-Comparators
Send for Illustrated
Controls Handbook ***Dept. H***

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27 March 1959

Readers' Service

Information Requisition

Use this easy self-mailer to obtain further information about items or literature from the Equipment section as well as from advertised products.

EQUIPMENT

Circle below desired number corresponding to:

684	693	696	706	707	708	709
717	718	720	722	724		

ADVERTISERS IN THIS ISSUE

In the below list, check page number of advertiser from whom you would like more information. If more than one item appears in ad, letters **A, B, C** are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **U** indicates upper ad, **L** lower ad, **I** inside ad, **M** middle ad, and **O** outside ad. The covers are designated by **IFC** (inside front cover), **IBC** (inside back cover), and **OBC** (outside back cover). Advertisements in Personnel Placement and Market Place are not keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

☐ IFC	☐ 804	☐ 806	☐ 845, UI	☐ 845, UO
☐ 845, L	☐ 846, UO	☐ 846, UI	☐ 846, LO	☐ 846, LI
☐ 847	☐ 848	☐ 849, UI	☐ 849, LI	☐ 849, O*
☐ 850, U	☐ 850, L	☐ 851	☐ 852, UO	☐ 852, LO
☐ OBC				

WHAT MAKES A COMPANY GROW?

Recently the top executives of several large corporations were asked what factor had played the most important part in the growth of their respective firms. Almost to a man the answer was the development of new products. Most said that ten years ago their companies were selling less than 50 percent of the products they now market.

It's no wonder then that industry is now spending money at a feverish pace to develop new materials and equipment which will insure their future markets. In fact, so cognizant is big business of the need for this type of research that this year industrial research expenditures will reach a new all-time high.

Of course, developing new products in the research laboratory is only half the battle, for industry must also find some way of exploiting all the possible applications that exist for their new discoveries. Ironically enough the effort to keep new developments flowing from the research laboratories has far exceeded the attempts to find applications for them. While enormous amounts are spent in new developments, very little is spent in getting the information about these developments to every research scientist who might find applications for them in other areas.

A few companies, realizing the necessity for keeping all scientists everywhere informed of their new discoveries, have developed a new approach to the problem. They have found that by using advertising space in a publication that scientists read, they can stimulate the use of their products in a wide variety of applications. Usually this type of advertising takes the form of a straight forward presentation of the product's possibilities along with its specifications. These firms report that this form of advertising has greatly increased the number of applications for their products in a relatively short period of time.

We are pleased that many of these firms have chosen the pages of *Science* Magazine to tell the research community about their latest achievements. It is even more gratifying that *Science* has been able to justify the confidence of these companies. Time after time research men from every field of research have showered these companies with requests for samples or more information about their new products.

If your company is one of those which would like to be selling twice as many products in ten years as it does now, drop us a line to the address below. We will be happy to show you how your company can insure its future markets with a very modest expenditure.

OVER 60,000 SCIENTISTS READ SCIENCE EVERY WEEK

SEND FOR FREE BOOKLET "FACTS ABOUT SCIENCE" WHICH GIVES COMPLETE INFORMATION ON CIRCULATION & RATES

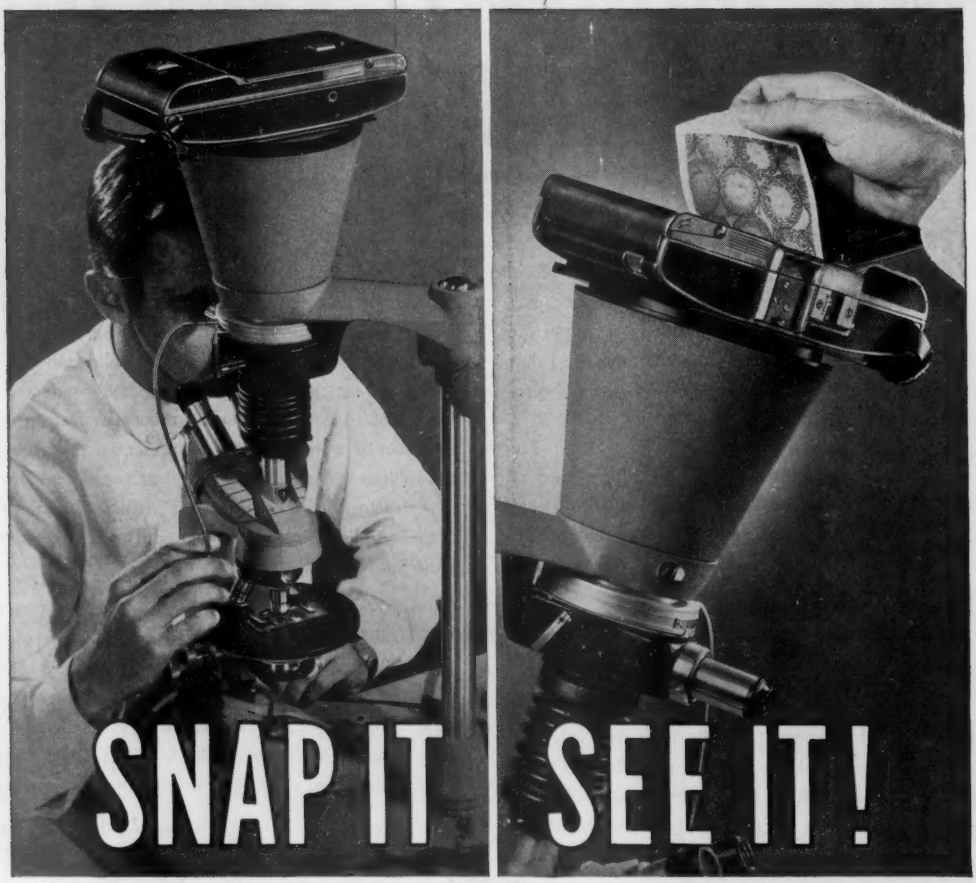
SCIENCE

The Weekly Magazine of Research

11 W. 42nd Street

N. Y. 36, N. Y.

D. Vass



AO Spencer Picture-in-a-minute Photomicrography

When you use the AO Spencer Photomicrographic Camera equipped with the Polaroid® Land Camera back, permanent photographs are ready for your files in just 60 seconds. A coupled visual and photographic system lets you shoot what you see . . . quickly and effortlessly. And with the Polaroid back possible errors in exposure, illumination or focus can be corrected immediately.

In addition to the Polaroid Land camera back, you have a choice of 4 other *readily interchangeable* camera backs; 4″ x 5″ fixed back; 4″ x 5″ Graflok back; 35mm back and Bantam back (roll film). You choose the camera back and film best suited to your specific requirements.

Here, the No. 682G Camera is being used with the AO Spencer Series 4 Microstar . . . an ideal combination. The built-in base illuminator provides convenient Koehler-type illumination. You select specimen area and do all preliminary focusing through binocular portion of trinocular body . . . focus critically with the telescopic eyepiece.

The sturdy vertical pillar, the easily adjustable camera support, the camera back and the Microstar all combine to provide a compact unit. Perfect alignment and rigidity is assured . . . successful photomicrography becomes a "snap".

Try it and see for yourself. Your AO Representative will be happy to arrange a demonstration for you.

AO SPENCER

American Optical Company

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Dept. O-4

☐ Please send me Brochure SB682 describing the entire line of AO Spencer Photomicrographic Cameras.

☐ Please send me Brochure SB124 describing the new Microstars.

Name_____

Address_____

City_____ Zone____ State____